WCH-207
Rev. 0

River Corridor
Closure Contract

Final Hazard Categorization for the Remediation of the 116-C-3 Chemical Waste Tanks

September 2007

Washington Closure Hanford

Prepared for the U.S. Department of Energy, Richland Operations Office
Office of Assistant Manager for River Corridor

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DISCLM-5.CHP (11/99)

WCH-207
Rev. 0

STANDARD APPROVAL PAGE

Title: Final Hazard Categorization for the Remediation of the 116-C-3 Chemical Waste Tanks

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DOCUMENT CONTROL mjp 09/10/07

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EXECUTIVE SUMMARY

This report presents the initial hazard categorization (IHC), final hazard categorization (FHC) for the remediation of the 116-C-3 Chemical Waste Tanks, located within the 100-B/C Area of the Hanford Site. These tanks are located within the 100-BC-2 Operable Unit.

The IHC for 116-C-3 was determined to be *Hazard Category 3*. Because the IHC was determined to be *Hazard Category 3*, the development of an FHC was required. This resulted in an FHC of *below Hazard Category 3* as a result of the analysis presented in this document. This FHC determination concludes that no activity or process authorized could credibly result in significant consequences to workers, the public, or the environment.

This analysis includes the following:

- A description of the remediation activities to be performed at the 116-C-3 Chemical Waste Tank waste site
- An assessment of the inventories of radioactive and other hazardous materials within the tanks
- Identification of the hazards associated with the remediation activities performed within the 100-B/C Area where the 116-C-3 site is located
- Identification of those accident scenarios with the potential to produce local significant consequences during remediation of 116-C-3
- An FHC calculation, based on the physical and chemical form of the radionuclides and the available dispersive energy sources associated with remediation activities
- Identification of special controls derived from the assumptions made in the FHC calculation that are required to ensure that the FHC remains valid
- Identification of project-specific controls established for the protection of the workers that apply specifically to the activities under consideration.

For hazardous chemicals identified during remediation, the sum of the ratios calculated for the IHC did not exceed 1 for either 29 *Code of Federal Regulations* (CFR) 1910.119 or 40 CFR 68.130 thresholds (29 CFR 1910 and 40 CFR 68). The FHC for the 116-C-3 Chemical Waste Tanks Remediation Project was determined based on a comparison of the radiological material at risk with adjusted DOE-STD-1027 (DOE 1997) threshold quantities. The Category 3 threshold quantities were adjusted based on the credible release fractions associated with remediation activities. This analysis has determined that the FHC for 116-C-3 is below Category 3 (sometimes referred to as "radiological"). To ensure that the conditions assumed in the hazard analysis are maintained, the controls, commitments, and conditions of approval in the safety evaluation report shall be incorporated into the project's readiness assessment to be completed prior to commencement of the work.

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REVISION HISTORY

Revision	Date	Reason for Revision	Revision Initiator
0	July 2005	Initial issuance, issued as BHI-01774	NA
0	August 2007	Document title was revised. Document number was changed, consequently, this is Revision 0. Incorporates the following Hazard Categorization Evaluations (HCEs): • HCE-2007-0004. Section 3.1 was revised to describe the use of cutting tools (e.g., plasma arc , water-jet cutting) for removing portions of the tops of the tanks. • HCE-2007-0011. Section 3.1 was revised to discuss the use of the northern (essentially empty) tank as a mock-up facility for remediation of the southern tank. • HCE-2007-0029. Change reference of old Bechtel Hanford Incorporated procedures to new Washington Closure Hanford procedures throughout the document. Consequently, the discussion of Management of Change process was replaced with a discussion of Hazard Categorization Evaluation process, throughout. • HCE-2007-0032. Correct error in reporting the diameter of the tanks in Sections 2.3.1 and 4.4.2. • HCE-2007-0034. Change the frequency of surveillances discussed in Section 5.2.10.	J. D. Ludowise

ACRONYMS

ALARA	as low as reasonably achievable
ARF	airborne release fraction
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FHC	final hazard categorization
HAMMER	Hazardous Material Management and Emergency Response
HMS	Hanford Meteorological Station
ICP	inductively coupled plasma
IHC	initial hazard categorization
MAR	material at risk
MEF	Metals Examination Facility
OU	operable unit
PPE	personal protective equipment
RadCon	Radiological Control
RCM	Radiological Control Manual
RCRA	*Resource Conservation and Recovery Act of 1976*
RV	release value
RWP	radiation work permit
SAP	sampling and analysis plan
SS HASP	site-specific health and safety plan
TQ	threshold quantity
WCH	Washington Closure Hanford

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	millibecquerel	millibecquerels	0.027	picocuries

1.0 INTRODUCTION

This final hazard categorization (FHC) document examines the hazards, identifies appropriate controls to manage the hazards, and documents the commitments for the 116-C-3 Chemical Waste Tanks Remediation Project. The FHC is based on the hazards associated with natural phenomena and remediation activities to be conducted at the 100-B/C Area where the 116-C-3 site is located. The remediation activities analyzed in this FHC are based on recommended treatment and disposal alternatives described in the *Engineering Evaluation for the Remediation of the 116-C-3 Chemical Waste Tanks* (BHI 2005e).

1.1 PURPOSE

This report accomplishes the following:

- Describes the activities to be performed during remediation of the 116-C-3 Chemical Waste Tanks addressed by this FHC
- Assesses the inventory of radioactive and other hazardous materials associated with the 116-C-3 Chemical Waste Tanks
- Identifies internally and externally initiated accident scenarios with the potential to produce significant consequences during remediation of the 116-C-3 Chemical Waste Tanks
- Determines an FHC based on a comparison of the material at risk (MAR) with DOE-STD-1027 (DOE 1997) Category 3 threshold quantities (TQs), adjusted to reflect the credible release fractions for remediation activities
- Identifies the necessary controls to manage the hazards and to ensure that the FHC remains valid.

1.2 DOCUMENT ORGANIZATION

Section 1.3 describes the project activities that will be authorized by approval of this document. Section 1.4 describes how configuration and change control will be managed to maintain compliance with the requirements of this document. Section 1.5 summarizes the conclusions and project-specific controls. Section 1.6 describes the overall approach used in the FHC process. Section 2.0 provides the background information necessary to understand the hazards that have potential consequences to workers, the public, or the environment. Section 3.0 describes the operations that are analyzed and authorized under the FHC document. Section 4.0 identifies the hazards present, analyzes the identified hazards, and provides the FHC. Section 5.0 describes special controls required to ensure the FHC remains valid, project-specific controls, and programmatic controls. Appendix A identifies the inventory of hazardous substances, sources of energy, and nonroutine hazards unique to the site. Appendix B identifies a systematic examination of the hazards that could potentially lead to a release of hazardous substances, ranking of events, and administrative controls that serve to eliminate or reduce the frequency of these events. Appendix C provides the quantitative accidents analysis;

defines the potential impacts of the site based on a bounding, unmitigated release of radioactive material; and provides the adjusted threshold quantities, which form the basis for the FHC.

1.3 AUTHORIZED ACTIVITIES

The scope of this document involves evaluating the hazards associated with the remediation activities for the 116-C-3 Chemical Waste Tanks. The remediation activities include the following general activities, which are further described in Section 3.0:

- Mobilization
- Excavation of soils, piping, tanks, and underlying soil
- Dust suppression
- Waste treatment
- Spill cleanup, if required
- Characterization and stabilization
- Material handling and transportation
- Decontamination
- Waste transportation
- Closeout sampling and surveying
- Placement of backfill
- Demobilization.

1.4 FINAL HAZARD CATEGORIZATION EVALUATION PROCESS

Established configuration/change control processes are in place that allow evaluation of proposed changes or discovered conditions that may affect the assumptions, controls, or other commitments as identified within this FHC document. If these commitments are violated, work will cease so that stabilization and/or recovery actions may be identified and implemented, as appropriate. Washington Closure Hanford (WCH) off-normal event procedures describe the reporting process and protocol applicable to such a discovery. NS-1, *Nuclear Safety Manual*, NS-1-2.1, "Hazard Categorization," defines the FHC evaluation process for facilities that have an FHC of "below Category 3."

1.5 SAFETY SUMMARY

Following a detailed analysis of the potential hazards that could be encountered while remediating the 116-C-3 Chemical Waste Tanks, it was determined that no activity or process authorized by this FHC could credibly result in significant consequences to workers, the public, or the environment (see Section 4.0). Project-specific controls are detailed in Section 5.1, and programmatic controls are detailed in Section 5.2.

1.6 HAZARD CATEGORIZATION

The initial hazard categorization (IHC) for the 116-C-3 Chemical Waste Tanks is Category 3 (BHI 2005d). The FHC for the remediation of 116-C-3 was determined to be below Category 3 (sometimes referred to as radiological). The FHC (Appendix C) for the 116-C-3 Chemical

Waste Tanks Remediation Project was determined using the total radionuclide inventories and the Category 3 TQs from DOE-STD-1027 (DOE 1997) adjusted to reflect credible release fractions (BHI 2005b).

2.0 BACKGROUND INFORMATION

2.1 HANFORD SITE HISTORY

From 1943 until 1990, the primary mission of the Hanford Site was to produce nuclear materials for the defense of the nation. Waste disposal activities associated with this mission resulted in the creation of more than 1,000 past-practice waste sites. The waste sites are contaminated with radioactive constituents, chemical constituents, or combinations of both.

The U.S. Army Corps of Engineers established the Hanford Site in 1943 as an integral part of the Manhattan Engineering District mission to produce nuclear weapons for use in World War II. The Hanford Site, then referred to as the Hanford Engineer Works, had a specific mission: the production of weapons-grade plutonium to fuel the nation's nuclear arsenal. This was accomplished through a three-step process that involved the manufacturing of fuels in the 300 Area, irradiation of fuels in the 100 Area reactors, and the extraction and production of plutonium at the chemical separations plants in the 200 Areas.

The 100 Areas of the Hanford Site were placed on the U.S. Environmental Protection Agency's (EPA) National Priorities List on November 3, 1989, under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). A subset of the Hanford Site waste sites on the National Priorities List also falls under the jurisdiction of the *Resource Conservation and Recovery Act of 1976* (RCRA).

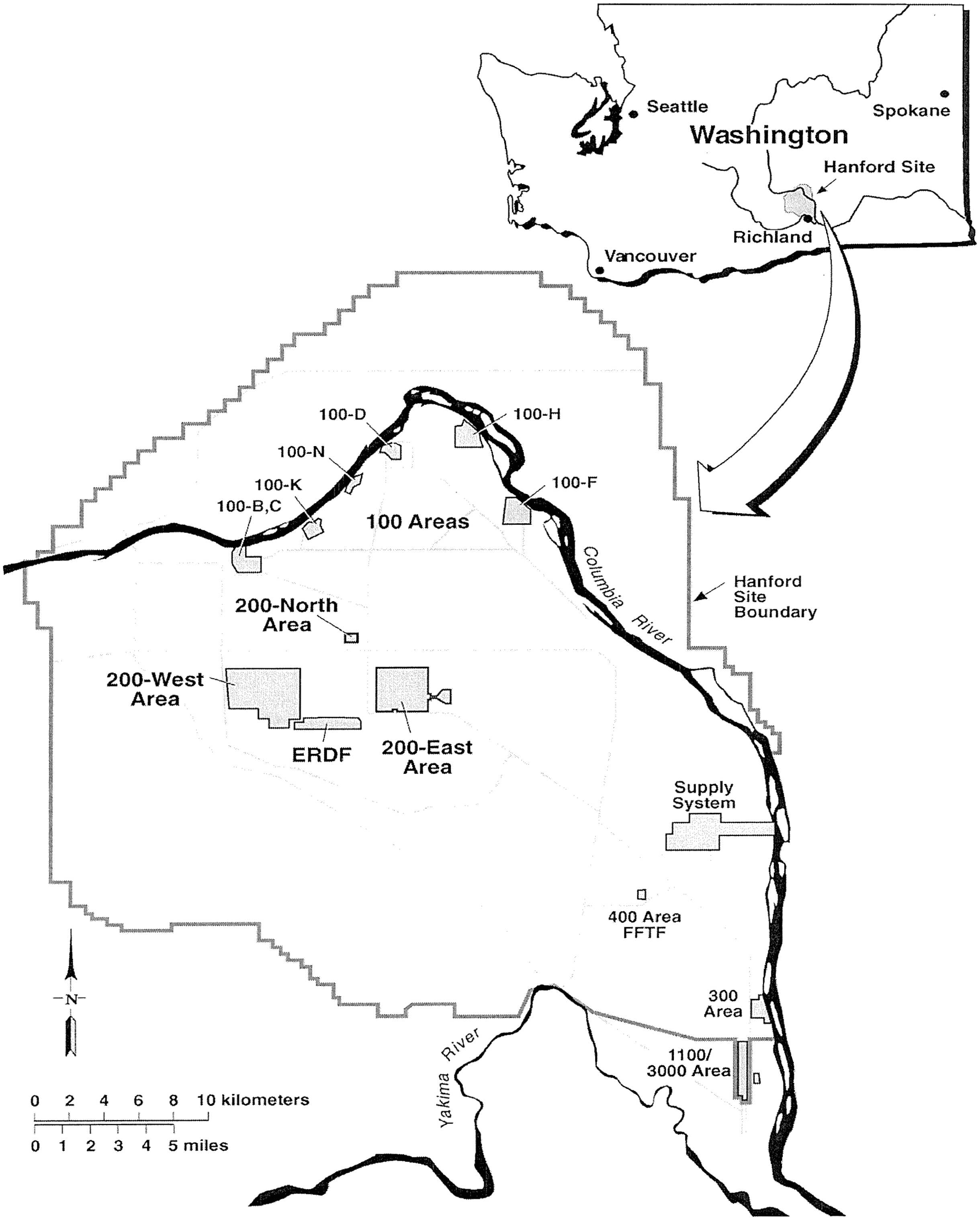
2.2 100-B/C AREA

The 100-B/C Area is located along the northern boundary of the Hanford Site (Figure 2-1), with its northern border delineated by the southern bank of the Columbia River. This area contains two of the Hanford Site's surplus nine plutonium production reactors.

Signatories to the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) developed a coordinated CERCLA/RCRA site remediation and remediation strategy to comprehensively and expeditiously address environmental concerns associated with the Hanford Site. This strategy, known as the *Hanford Past-Practice Strategy*, emphasizes integration of the results of ongoing site remediation activities into the decision-making process as soon as practicable (a procedure called the "observational approach") and expedites the remedial action process by emphasizing the use of interim actions.

Investigation and remediation of the past-practice waste sites is governed by the *Hanford Federal Facility Agreement and Consent Order*, initially signed in 1989 by the U.S. Department of Energy (DOE), EPA, and the Washington State Department of Ecology. This agreement grouped the waste sites into 78 operable units (OUs), each of which was to be investigated and remediated separately under the CERCLA program or the RCRA program, depending on the designation of the OU.

Figure 2-1. The Hanford Site.



Like each of Hanford's National Priorities List sites, the 100 Area was divided into OUs, which are groupings of individual sites based primarily upon geographic area and common waste sources. Geography also played an important role in the grouping of individual sites into OUs. Because it may be difficult to assess the environmental impacts of one site without obtaining information about other sites in the vicinity, grouping adjacent sites into OUs allows the impacts of the sites to be assessed as a group rather than on an individual basis.

2.3 PROJECT DESCRIPTION

2.3.1 116-C-3 Chemical Waste Tanks Site Description

The 116-C-3 Chemical Waste Tanks are located in the 100-BC-2 OU in the 100-B/C Area and were installed in 1955 (Figure 2-2). The 116-C-3 Chemical Waste Tanks are located northeast of the 105-C Reactor Building, just outside the exclusion area fence. The tank area is bounded by 7.6-cm (3-in.) yellow steel posts. The site currently appears as a vegetation-free, cobble-covered field showing evidence of the excavation activities from November 2004. Although not backfilled to match the surrounding grade, the tanks are below grade and are not visible (Figures 2-3 and 2-4).

The 116-C-3 waste site consists of two underground chemical waste storage tanks, referred to as the north tank and the south tank. The tanks are cylindrical in shape with domed ends and are positioned horizontally. Each tank is 3.5 m (11.5 ft) in diameter, approximately 11 m (36 ft) in length, and has a nominal capacity of 102.2 kL (27,000 gal). In November 2004, the liquid depth in the north tank was measured at 3.2 cm (1.25 in.) and 1.25 m (4.1 ft) in the south tank. The solids-to-liquid ratio in the sample collected from the south tank is 3 g/L. This equates to 540,000 g (1,190 lb) of sludge to 34,800 L (9,193 gal) of liquid in the tanks. Based on historical Hanford Site drawings, the tanks are spaced about 2.4 m (8 ft) apart (Figures 2-5 and 2-6). They are constructed of 9.5-mm (3/8-in.)-thick carbon steel, and the piping associated with the tanks is stainless steel. Although the tops of the tanks were originally approximately 3.1 m (10 ft) below surrounding grade, they were only partially backfilled following November 2004 sampling and are now about 1 m (3 ft) below grade (Figure 2-3). Each tank has a 0.76-m (30-in.) manhole with a gasketed cover located at one end of the top of the tank. There are also six nozzle openings along the length of the top of each tank, ranging in diameter from 7.6 cm (3 in.) to 15.2 cm (6 in.). Two steel vent pipes (one for each tank) approximately 3.7 m (12 ft) tall extend upward to about 0.6 m (2 ft) above the surrounding grade.

Three rusted valve handles, approximately 0.9 m (3 ft) tall, protrude from the center of the west half of the tank site. A gray 5-cm (2-in.) conduit pipe protrudes from the center of the east half of the waste site. This pipe is part of the cathodic protection system that was installed to protect storage tanks against corrosion. The site is posted with a sign identifying it as the "116-C-3 Chemical Waste Tanks." The site includes all underground pipelines between the 116-C-3 (105-C) chemical waste tanks to a valve upstream from the south tank.

Figure 2-2. 100-BC-2 Operable Unit and 116-C-3 Site Location.

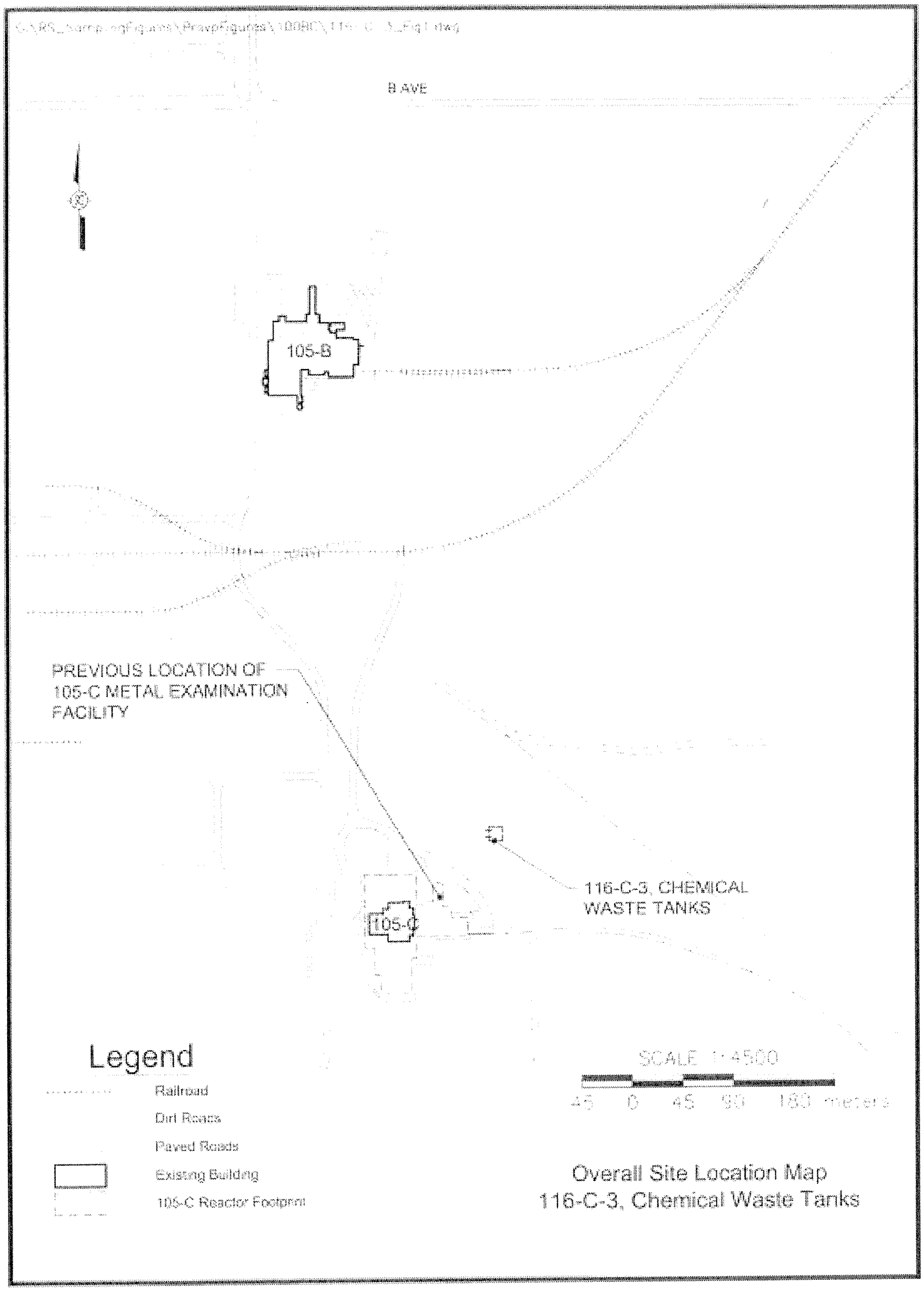


Figure 2-3. 116-C-3 Tank Area Looking East – Photograph Taken March 21, 2000.

Figure 2-4. 116-C-3 Tank Area Looking Northeast – Photograph Taken March 21, 2000.

Figure 2-5. Current Configuration of the 116-C-3 Chemical Waste Tanks (Plan View).

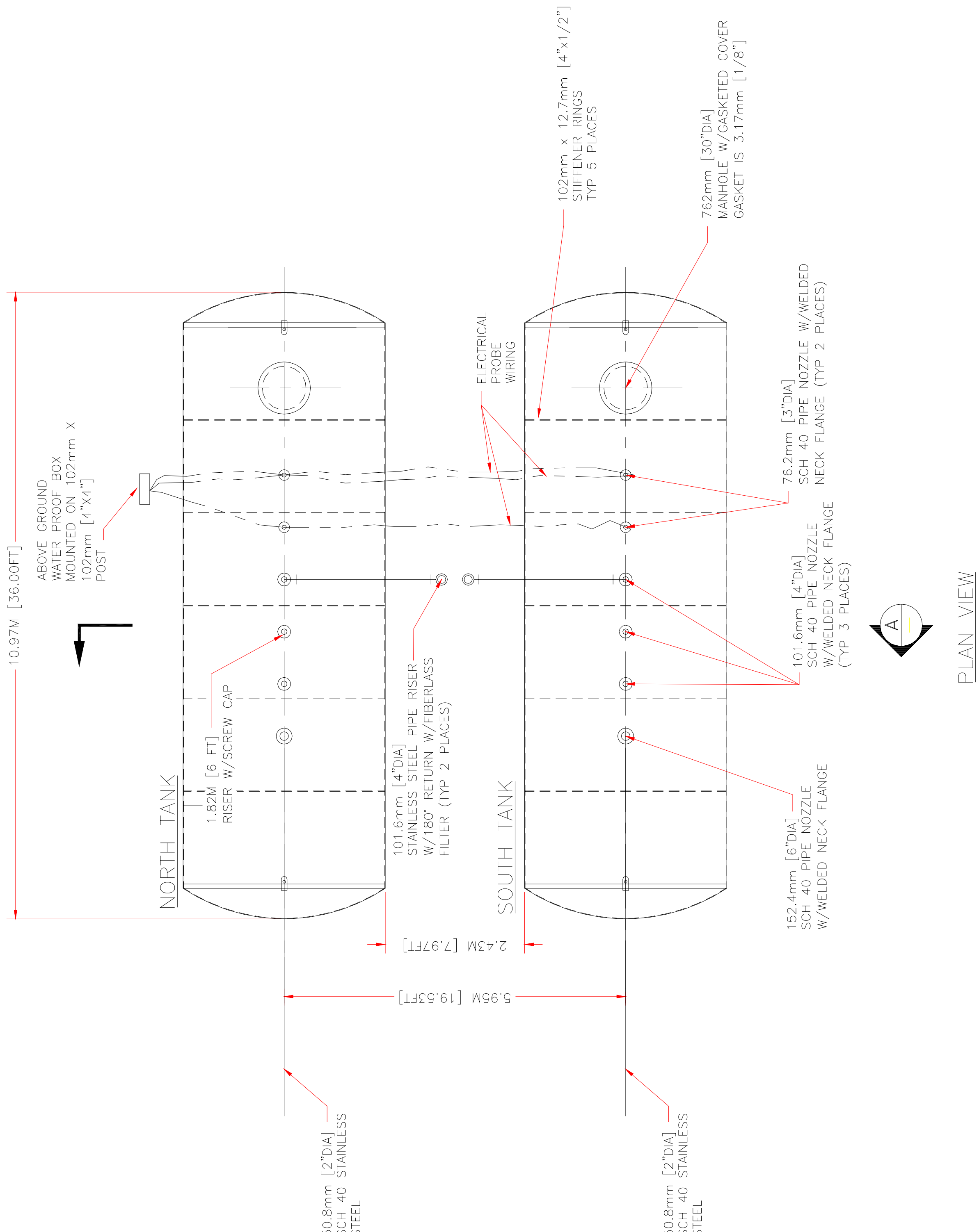
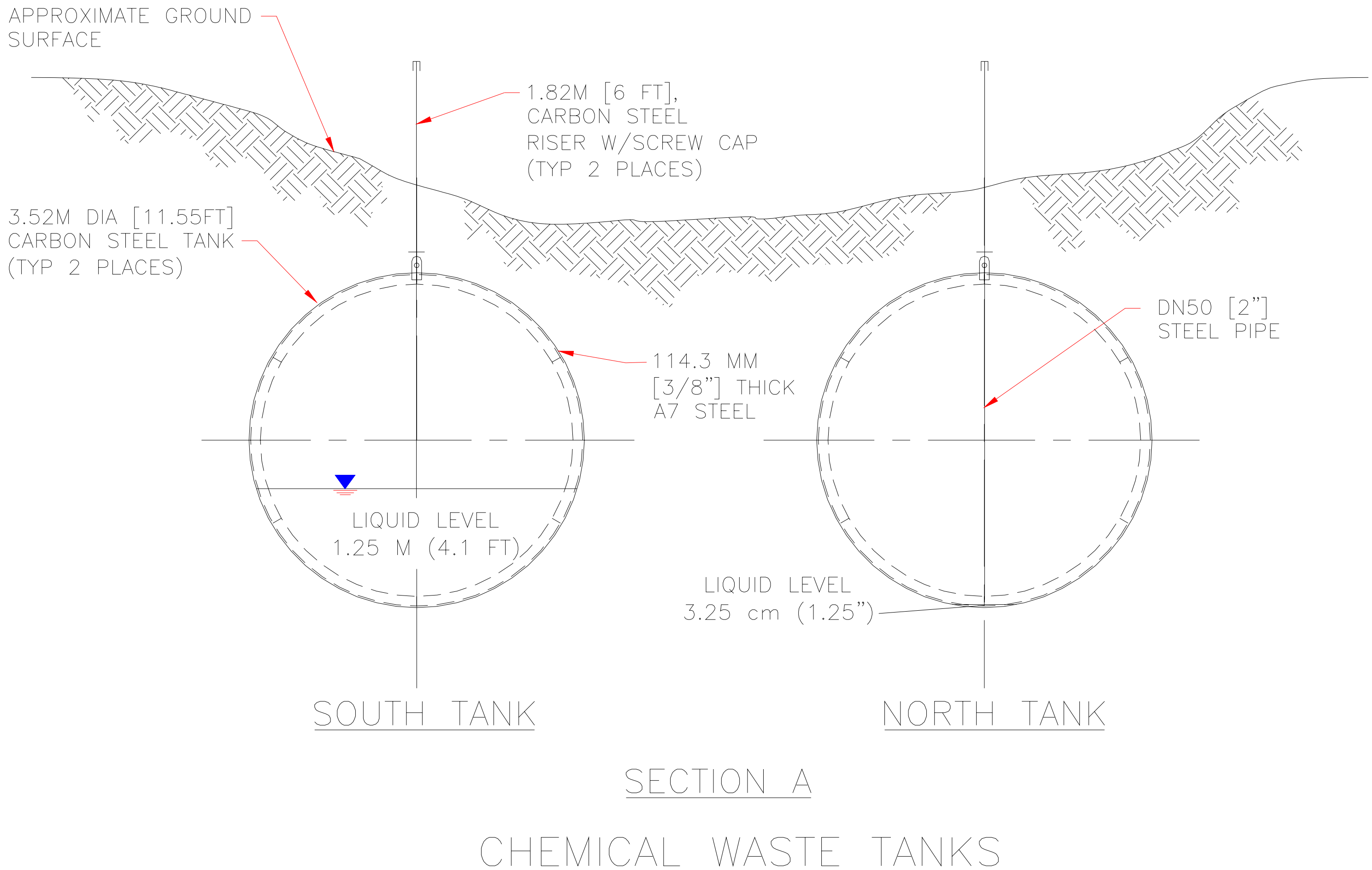


Figure 2-6. Current Configuration of the 116-C-3 Chemical Waste Tanks (Section View).



A 5-cm (2–in.) Schedule 40 stainless steel valve bypass line connected the 105-C Metals Examination Facility (MEF) to the two 116-C-3 Chemical Waste Tanks (see Figures 2-5 and 2-6). This pipeline was removed as part of remedial action activities for the pipelines. In July 2000, the vents were sealed with aluminum tape as a preventive measure for potential passive radioactive emissions.

2.3.2 116-C-3 Operational History

The tanks were designed to receive liquid wastes from the MEF. The MEF was part of the 105-C Reactor Building and was designed to examine and test irradiated fuel elements. Examination and testing sometimes involved mechanical removal of the end caps of the fuel slugs and the chemical dejacketing of the remainder of the fuel slugs.

Chemical dejacketing consisted of immersion of the fuel slugs in 50% (by weight) sodium hydroxide for a predetermined reaction time. The sodium hydroxide was then drained into the 116-C-3 tanks and the slugs were rinsed with water. A second immersion in 50% sodium hydroxide, with the addition of steam to promote the jacket removal reaction, was followed by a second water rinse. The slugs were then cleaned with a 10% (by weight) solution of nitric acid, followed by several additional water rinses.

Historical documentation varies as to whether the tanks were ever used. According to the Waste Information Data System, the tanks were never used, and liquid wastes from the MEF were instead routed to the 116-C-2A Pluto Crib. However, positive results from the survey data (smear samples) as well as declassified documents regarding operations and process historical data demonstrate that the tanks were used as liquid waste receivers for chemical dejacketing waste.

2.3.3 116-C-3 Characterization Activities

To verify whether the tanks were ever used, characterization activities were performed in November 2004. Smear samples taken from the inside of one of the valve nozzle pipes from one of the tanks and analyzed in the field indicated the presence of low levels of alpha- and beta-gamma-emitting radionuclides. Additional analysis identified the presence of cesium-137, plutonium-239, and americium-241. A current estimate of the inventory associated with this site, based on process knowledge of the activities that fed into these tanks, is documented in (BHI 2005d).

2.3.4 Sampling Activities and Results

Sampling conducted in March 2003 (BHI 2003) detected elevated alpha and beta/gamma contamination in smear samples from the inside of the valve of the south tank, and the results are presented in Appendix B of BHI (2005e). Two smear samples were analyzed. Cesium-137 and americium-241 had detectable activities in the gamma energy analysis, and plutonium-239 and americium-241 were detected qualitatively in the alpha energy analyses. Based on these results, additional sampling was recommended.

Sampling of the contents of each tank was performed in October and November 2004 to support waste characterization and evaluation of potential waste disposition alternatives for the tanks (BHI 2004b, 2005a). In preparation for sampling, a trench was excavated approximately 3.1 m (10 ft) to the overflow pipe between the two tanks. The length of the overflow pipe was excavated, and the top of the south tank was exposed around the nozzle. Radiological screening results of the overflow pipe with a radiation detection instrument were negligible near the north tank and 3 mR beta/gamma at contact with the south tank. To complete preparations for sampling, the overflow pipe connecting the two tanks was removed to allow access to the tank interiors, and vertical stainless steel nozzle extension pipes were bolted to the existing overflow pipe flanges on the top of each tank to facilitate sampling. The ends of the removed overflow pipe were then sealed, the pipe was placed into the excavation, and 0.9 m (3 ft) of soil overburden was placed into the trench, covering the detached overflow pipe (Figure 2-3). Before collection of confirmation samples, the tanks were accessed through the riser to obtain pH readings, measure waste depths, and collect smear samples from the interior surfaces. Both tanks were found to contain liquid. The depth of the liquid in the north tank was approximately 3.2 cm (1.25 in.), and the depth of the liquid in the south tank was approximately 1.3 m (4.1 ft).

To collect samples of the contents of the south tank, peristaltic pump tubing was lowered into the tank and a representative sample of the liquid was pumped from varying depths in the waste column into a 3.8-L (1-gal) cubitainer and dispensed into bottles. The south tank liquid was described as a clear liquid with a yellowish-green cast that turned black when the solid material on the bottom of the tank was pumped into the cubitainer and resuspended in the liquid. The solids were separated from the liquid through filtration to facilitate separate analyses. The liquid was analyzed for volatile organics, polychlorinated biphenyls, inductively coupled plasma (ICP) metals and mercury, gamma energy analysis, gross alpha and beta, radionuclide, nitrate, and pH. Solids were analyzed for ICP metals and radionuclides.

To collect samples of the contents of the north tank, peristaltic pump tubing was lowered into the tank and a rust-colored liquid was pumped from the tank into a 3.8-L (1-gal) cubitainer and then dispensed into a bottle. Because of the shallow liquid depth in the tank and because the nozzle was slightly offset from center, only enough liquid could be pumped out of the north tank for collection of a 20-mL sample. Because of insufficient sample volume, the requested laboratory analytical list was prioritized and restricted to analysis of ICP metals and mercury. It was determined that additional sampling of the north tank was not needed due to the limited material in the tank available for sample collection and because field radiological measurements collected during confirmatory sampling indicated no significant radiological activity in smear samples.

The newly installed risers were capped following sample collection.

2.3.4.1 South Tank. Data from smear samples collected from the interior surfaces of the south tank indicated 20,000 pCi/g cesium-137 and approximately 3,000 pCi/g strontium-90 (BHI 2005e). The analytical results for liquid collected from the south tank indicate that the contents are mixed waste due to the presence of radionuclides and chemical constituents. Chromium was measured in the sample at 5.77 mg/L, and lead was measured at 2.26 mg/L. The pH of the sample was 13.2.

Highly dispersible sludge with an estimated thickness of approximately 13 mm (1 in.) was separated from the liquid sample and analyzed for metals and radionuclides. Chromium was measured in the sample at 1.36 mg/L, and lead was measured at 0.338 mg/L. The sludge by itself (i.e., separated from the supernate) contains transuranic radionuclide activity of greater than 100 nCi/g, which would define the material as transuranic waste if separated from the supernate.

2.3.4.2 North Tank. No significant detectable radiological contamination was detected in smear samples collected from interior surfaces or from field radiological measurements (BHI 2005e). The analytical results for liquid collected from the north tank indicate contaminant levels below action levels.

2.4 SEGMENTATION

No segmentation was applied in the determination of the FHC.

2.5 DEMOGRAPHICS

This section describes the local demographics in sufficient detail to understand the potential effect of these remediation activities upon downwind receptors. As concluded in Section 4.0, the resulting effects (consequences) of a potential release of hazardous materials are limited to a localized area contained within the remediation site boundary.

Population size and distribution are important criteria to assess the magnitude of risk to the public from radiological releases. Desert Aire and Mattawa are the closest populated areas to the 100-BC-2 OU and are approximately 20.33 and 21.89 km (12.63 and 13.61 mi) away from the 100-BC-2 OU, respectively. Approximately 376,000 people lived within a 80-km (50-mi) radius of the Hanford Meteorological Station (HMS) in 1990. As of 1999, about 17,000 people were employed on DOE-related projects at the Hanford Site.

Recreationists, consisting of hunters, fishermen, boaters, and off-road sports enthusiasts, enjoy activities throughout various parts of the area in proximity to the Hanford Site. The primary fishing season is June through November; the main hunting season is from October through January. The Columbia River, which is adjacent to the 100-BC-2 OU, is used for recreation and is open to the public. The heaviest use of the area by recreationists is on weekends and holidays, usually in the early morning.

Approximately 30 individuals will work on the 116-C-3 Chemical Waste Tanks Remediation Project, and up to 60 individuals will be working in the 100-B/C Area during 116-C-3 remediation activities.

2.6 SITE FEATURES

This section contains information on the meteorological and geological characteristics of the area.

2.6.1 Meteorology and Climate

The climate at the Hanford Site is a mid-latitude, semi-arid desert. The summers are usually warm and dry with abundant sunshine, while the winters are cool with occasional precipitation. Temperature extremes vary from -29°C to 46°C on the Hanford Site (Hoitink et al. 2005). Climatological data are available from the HMS (which is located between the 200 East and 200 West Areas on the Hanford Site) and from the 300 Area meteorological station. The HMS has collected data since 1945. Appendix A addresses the potential effects associated with exposure to heat/cold extremes.

2.6.2 Precipitation

Precipitation that infiltrates through the ground (i.e., recharge) has the potential to carry contaminants through the soil to the groundwater and the river. Average annual precipitation on the Hanford Site is 16 cm (6.3 in.). In 1995, the wettest year on record, 31.3 cm (12.3 in.) of precipitation was measured; in the driest year, 1976, only 7.6 cm (3 in.) was measured. Most precipitation occurs during the winter, with more than half of the annual amount occurring from November through February. Appendices A and B assess the potential effects associated with internal flooding and flooding caused by a probable maximum flood (see also Section 2.6.5).

January is the wettest month, with an average of nearly 100 hours of precipitation, producing just over 2.3 cm of water. Days with greater than 1.3 cm (0.5 in.) of precipitation occur less than 1% of the year (Hoitink et al. 2005). Appendix A provides an evaluation of water intrusion during remediation project activities. Topography within the 100 Areas is generally flat, gently sloping toward the Columbia River, with no obvious drainage channels. The flat topography, the lack of well-defined drainages, and the arid to semi-arid climate suggest that little (if any) surface water would accumulate within the site.

Mean annual run-off from the Pasco Basin is approximately 3% of the total precipitation. The remaining precipitation is assumed lost through evapotranspiration, with less than 1% recharging the groundwater system. Fayer and Walters (1995) estimated recharge at the 100-F Area as high as 55.4 mm/yr (2.2 in./yr) on disturbed, nonvegetated sites with Rupert sands. The presence of shrub-steppe and cheatgrass vegetation reduces infiltration. At a recharge rate of 55.4 mm/yr (2.2 in./yr), precipitation would take about 28 years to travel 7.6 m (25 ft).

2.6.3 Prevailing Winds

Historical meteorological data indicate that the prevailing winds align themselves with the Columbia River, traveling predominantly from the west and west-northwest. The wind speed averages 10 to 12 kph in the winter and 13 to 17 kph in the summer. The strongest winds are generally southwesterly, with speeds up to 130 kph. More than 90% of the southwesterly winds exceed 30 kph. The daily average wind speed at the 100 Area ranges from 8 to 16 kph.

High winds are likely to occur during site remediation activities. In the summer, high-speed winds from the southwest cause most of the dust storms. There is a remote possibility that high winds may also cause airborne missiles (e.g., scrap wood and miscellaneous items at the site). Blowing dust occurs at wind speeds higher than 30 kph in areas with limited ground cover and low moisture content. An average of eight dust storms per year is recorded at the HMS. A storm generally lasts just over 3 hours; however; durations of 18 hours have been documented. The maximum wind gust recorded at 15 m (49 ft) above ground surface at the HMS was 128 kph (Hoitink et al. 2005). A peak gust of 138 kph was calculated with a 100-year return period. The return period for gusts of 113 kph is 10 years (Stone et al. 1983).

2.6.4 Weather Phenomena

At the Hanford Site, dust storms are a severe weather phenomenon that occur most frequently and have the greatest potential effect.

A severe tornado of the Midwestern type is highly unlikely because of the Pacific Northwest's climatologic and topographic conditions. Only two tornado funnel clouds and one small tornado (June 1948) have been observed within the Hanford Site in the 34-year period between 1945 and 1978. On average, Washington State experiences just over one tornado each year. The probability of a tornado striking a point at the Hanford Site is estimated to be 9.6 by 10^{-6} per year. As stated in the environmental impact statement (DOE 1987), tornadoes are infrequent and generally small in the northwest portion of the United States.

Washington State has an annual mean number of thunderstorm days of 10, which is considered to be relatively low (IEEE 1991). Thunderstorms occur most frequently from April to September. Lightning strikes in the summer occasionally have ignited range fires in the Hanford Site region.

2.6.5 Hydrologic Description

The 116-C-3 Chemical Waste Tanks are situated within the Columbia River drainage basin. Two major rivers within the Columbia River drainage basin border the Hanford Site: the Columbia and Yakima Rivers.

The maximum floods on record occurred in 1894 and 1948, with peak flows at the Hanford Site estimated at 21,000 m^3/s and 20,000 m^3/s, respectively (Neitzel 1997). These floods occurred before the Priest Rapids Dam and several other upriver dams had been constructed.

The flow regulation resulting from the upriver dams significantly lessens the projected intensity of the potential 1,000-year flood to about 12,400 m^3/s. The regulated flood of 1997 was just under this level. Thus, a 1,000-year flood would not inundate any of the reactor areas or burial grounds (DOE 1996) because of the regulated flows.

Neitzel (1997) also discusses a potential flood caused by a 50% breach of the Grand Coulee Dam, caused by sabotage or war. This breach would cause a flow estimated at 600,000 m^3/s and would cause significant flooding, including (for the Hanford Reach area) the remainder of the 100 Areas, West Lake and Gable Mountain Pond, the 300 Area, and nearly all of Richland, Washington (DOE 1996). The potential effects from this scenario on waste site have not been considered further because "...a breach under these conditions would indicate an emergency situation in which there might be other overriding major concerns" (Neitzel 1997).

2.6.6 Geology and Seismology and Volcanology

The Hanford Site lies within the Columbia Intermontane Province, which is bordered on the north and east by the Rocky Mountains, on the west by the Cascade Range, and on the south by the Basin and Range Province. The dominant geological characteristics of the Columbia Intermontane Province have resulted from flood basalt volcanism and deformation processes.

The geologic structure beneath the 100 Area is similar to much of the Hanford Site, which consists of three distinct levels of soil formations: the deepest level is a series of basalt flows that have warped and folded over time. The top level is also a basalt layer, the top of which ranges in elevation from 46m (150 ft) below sea level, to 64m (210 ft) below sea level. The middle layer, known as the Ringold Formation, consists of silt, gravel, and sand.

The Hanford Site is in a seismic Zone 2b, as defined by the International Building Code (IBC 2000). Earthquake records for the Pacific Northwest extend to the 1850s. A network of seismographs was installed on the Columbia Plateau in 1969. Slope subsidence is the most likely result of seismic activity at a partially excavated burial ground. Seismic activity and related phenomena are not anticipated to result in significant radiological consequences to workers and the public from the 116-C-3 Chemical Waste Tanks Remediation Project because of the low energy of anticipated seismic activity and the form and distribution of the hazardous substances. In addition, it is not anticipated that multiple accident events would be initiated (similar to what may occur at a facility) as a result of a seismic event at the burial grounds.

The stratigraphic record in the Pasco Basin suggests that tephra is the only primary product of Cascade Range volcanism that may reach the Pasco Basin during the next 10,000 years. During the May 18, 1980, eruption of Mount St. Helens, about 7.6 mm (0.3 in.) of ash was deposited at the HMS tower. In the first 9 hours following the eruption, about 1 mm (0.04 in.) of uncompacted ash was recorded at the Energy Northwest Plant 2 meteorological station. Prevailing winds carried the majority of the ash cloud north of the Hanford Site.

Normal yearly snowfall is 35 cm (13.8 in.). The highest annual snowfall on record is 114.6 cm (45.1 in.), which occurred in 1916 (Hoitink et al. 2005).

2.6.7 Local Ecology

A species of concern near the 100-B/C Area is the federally protected bald eagle, generally found from November through March. Established bald eagle roosting and nesting sites are found near the 100-B/C Area, but the 116-C-3 Chemical Waste Tanks are not within the buffer zone established to protect the eagles.

2.6.8 Adjacent Facilities

It is unlikely that any accidents specific to facilities outside of the 100-BC-2 (e.g., explosions and spills) will impact the 116-C-3 site due to significant distances between this OU and surrounding facilities. The most probable impacts would be an evacuation as a result of a release of inventory from a nearby facility due to an accident or a fire. No activities are being carried out at the 116-C-3 site that would be adversely impacted if an evacuation were required. A release of inventory from a nearby facility would not interact with the MAR at the remediation sites. In addition, there are no facilities close enough to the 116-C-3 site to be affected by accidents at the 116-C-3 site. Therefore, based on the above discussion, no significant adverse impacts on the remediation site would occur from other projects on the Hanford Site.

3.0 OPERATIONS

All 116-C-3 remediation activities will conform to the WCH work process controls and procedures that guide all site activities.

3.1 PROJECT ACTIVITIES

The 116-C-3 Chemical Waste Tanks Remediation Project involves three distinct phases: mobilization, remediation, and demobilization/closeout. This FHC is primarily concerned with the identification and evaluation of radiological hazards associated with the remediation phase of the work.

The preferred remediation and disposal option is solidification (e.g., grouting) of the tank contents. If not completely filled during placement of solidification agent, a fixative agent may be applied to the upper levels of the interior tank surfaces (north and south). This step will capture and fix in place any residual smearable and potential airborne contamination inside of the tanks before size-reduction activities are performed. Heavy equipment (e.g., plate shears in the universal processor of an excavator) will be used for sectioning the tanks, and either metal sheers or a bucket and thumb arrangement will be used to load out the sectioned pieces. Size reduction using shears will involve first separating the metal tank material from the solidified contents at the 116-C-3 site. The tank metal will be reduced in size sufficiently to place into one or more Environmental Restoration Disposal Facility (ERDF) containers. The remaining solidified waste monolith (if not broken during separation from the tank) will be covered with a layer of soil or dust suppressant to minimize air emissions and provide shielding, and then rubbilized with blows from the bucket of the excavator. The mixture of soil and rubbilized waste monolith would then be loaded into ERDF containers for transport and disposal to ERDF. It is assumed that the tank and solidified contents would meet the ERDF waste acceptance criteria (BHI 2005c).

The northern (essentially empty) tank may be used as a mock-up test facility for the dry materials addition operation. Activities on the northern tank would be similar to those described for the southern tank, except that about 34,000 L (9,000 gal) of water would be added to the northern tank to simulate the liquid in the southern tank.

Remediation activities include the following, as appropriate:

- Excavation using backhoes and other heavy equipment to access inactive transfer lines, tanks and process equipment
- Use of decontamination techniques appropriate for areas that contain airborne or loose contamination
- The use of cutting tools (e.g., plasma arc torch, water-jet cutting) to remove portions of the top of the tank may be performed to facilitate detailed characterization and tank material treatment/removal
- Size reduction (e.g., hydraulic shears, grinders, snippers, wire saws, mechanical disassembly, rubbilizing of solidified tank contents) and removal of tank and contents,

structural components, concrete, underground transfer lines, including use of temporary enclosures and vacuum systems, as necessary, for control of radiological contamination

- Removal of steel, inactive process equipment, transfer lines, and waste containers
- Backfilling of trenches created as a result of the remediation of tanks and transfer lines
- Installation of radiological control areas (e.g., radiological buffer areas), as necessary, during remediation activities
- Periodic or continuous health and safety monitoring activities, as required (e.g., site-specific health and safety plan [SS HASP], radiation work permit [RWP], site-specific instructions)
- Loading of tank sections and rubbilized waste debris into ERDF containers or other approved packaging for transportation and disposal
- Use of dust-suppression techniques during remediation activities. Removed debris (e.g., tank, piping, and other contaminated materials) will be staged temporarily in ERDF containers, waste drums, or other approved containers before final disposition.

3.1.1 Mobilization

Mobilization typically includes the establishment of infrastructure that is needed to support the conduct of remediation activities, such as the following:

- Installation of diesel- or gasoline-powered generators, if required, to provide temporary power for remediation activities
- If required, installation of personnel changing/shower/rest rooms/personal protective equipment, lunchroom, and administrative facilities (typically portable trailers)
- Staging of heavy equipment (e.g., backhoes, cranes, excavators) for removal of piping, transfer lines, and sheared tank sections
- Installation of industrial safety and radiological monitoring equipment (e.g., specified in the SS HASP, RWP, or other approved safety documentation)
- Staging of maintenance and support equipment.

3.1.2 Excavation

The appropriate equipment to support excavation activities will be available. Any additional unique equipment required to support the work activities at the site will be evaluated to ensure that any critical assumptions identified within the FHC are not affected. The initial remedial investigation activities have been completed. Areas with known contamination will be excavated to a predetermined depth with the appropriate surveys conducted.

Field screening will be ongoing throughout the excavation phase. If contaminated materials are found, they will be placed into transfer containers for shipment to ERDF or other disposal sites. The uncontaminated soils will be stockpiled for site backfill when all of the contaminated soils, if any, have been removed. Contaminated debris (e.g., tank and pipe materials) will be cut, as necessary, and placed into ERDF containers for shipment to ERDF.

Visible dust emissions from the 116-C-3 site is not permitted. At active excavations water or other methods shall be used, as approved, for dust control in accordance with agreements between the DOE, Richland Operations Office, EPA, and the Washington State Department of Health. Water usage for dust control shall be minimized to protect against contaminant migration. Crusting agents or fixants shall be applied to any disturbed portion of the contamination area, if any, that will be inactive for more than 24 hours. Material to be disposed of at ERDF shall also comply with the moisture content and other applicable requirements of the ERDF waste acceptance criteria.

3.1.3 Dust Suppression

Two methods of dust suppression may be used for the 116-C-3 Chemical Waste Tanks Remediation Project. The first method is water application. Water is generally applied at the excavation dig face, on haul roads, parking lots, etc., whenever dust can be generated during the project. The second method is the use of crusting agents. A fixative (crusting agent) will be applied to a trench face before periods of inactivity longer than 24 hours and when sustained wind speeds over 20 kph (12 mph) are forecasted for the 100 Areas.

The project will receive daily weather forecasts from the HMS, which will provide the predicted sustained wind velocity forecasts. Decisions to apply crusting agents will be based on these forecasts. In addition, the project will also be on the call list for weather advisories and will use those reports for decision making.

3.1.4 Waste Treatment

Materials contaminated with chemicals at levels exceeding waste disposal acceptance criteria will be treated by fixatives/solidification/stabilization or other appropriate treatment technology. Solidification and stabilization are treatment technologies designed to reduce contaminant solubility, mobility, and toxicity through chemical or physical changes. Typical solidification and stabilization agents include cement-based materials (i.e., grout), clays, asphalt, and resins (e.g., epoxies). Contaminated materials treated to meet applicable treatment standards will be disposed of in the same manner as other materials that meet waste acceptance criteria without treatment.

During the solidification process, contaminated waste may be temporarily removed from the tank (e.g., via hoses or flexible piping), treated with solidification agent, and returned to the tank. In addition, materials may be removed from the tank to perform treatability testing.

Mixing of solidification agent and tank waste will be performed during waste treatment (e.g., compressed gas, mechanical mixers).

The selected remedy (in accordance with the record of decision) is currently to remove, treat (if required), and dispose. For purposes of the design basis, "treatment as required" has two main components: (1) treatment to reduce volume of contaminated waste, thereby lowering remediation costs, and (2) treatment as a regulatory requirement (e.g., dangerous waste).

3.1.5 Volume Reduction

Waste volume reduction practices, such as size reduction, decontamination (if feasible or practical), minimizing cross-contamination during remedial action, or segregation of clean overburden from contaminated materials, will be implemented, as appropriate.

3.1.6 Anomalous Waste

Anomalous waste (i.e., waste that needs additional characterization and/or treatment) is not anticipated at this waste site. However, if encountered, anomalous waste will be set aside in staging piles or containers within a staging pile area. Unknown anomalous waste will be characterized more extensively through a combination of field screening or analytical laboratory characterization, using a graded approach as described in the *100 Area Remedial Action Sampling and Analysis Plan* (SAP) (DOE-RL 2005). In addition, a site-specific SAP will be prepared for the 116-C-3 waste site.

3.1.7 Limited Characterization

Additional field investigation activities may include test pit excavation, field radiological screening, and collection/analysis of samples. Findings from the field investigations will be evaluated and incorporated through the FHC evaluation process.

3.1.8 Stabilization

Some waste materials will require stabilization to maintain worker exposure to airborne contaminants and/or direct radiation as low as reasonably achievable (tank liquids and sludges). As discussed previously, stabilization methods may include the use of solidification agents to encapsulate particulates and/or to provide shielding. Other methods of fixing contamination such as coatings or expandable foams will also be used on the internal surfaces of the tanks and ancillary piping systems, as appropriate. Exposed soil surfaces will be stabilized through the application of soil fixatives if the site is to be left unattended for greater than 24 hours or the meteorological forecast includes a high-wind warning.

3.1.9 Material Handling and Transportation

Material-handling and transportation activities will be performed inside the 116-C-3 area of contamination and staging pile area. Contaminated materials are loaded into the shipping containers (provided by ERDF) and moved by haul truck to the survey station. At the survey station, the loaded shipping containers are surveyed to verify that the outside is free of radiological contamination. If noncontaminated, the containers are moved to the transfer station where an ERDF haul truck picks up the container. When necessary, decontamination will be conducted. Transportation to the disposal facility is provided by ERDF. The project and ERDF ensure that all appropriate shipping requirements, including use of appropriate shipping containers and labeling, are met. Containerized waste may also be temporarily stored at the waste site to accommodate surveying and loading schedules.

Certain bulky items that exceed the capacity of standard ERDF containers (e.g., large metal objects, piping, concrete sections) may be size reduced, packaged, and shipped in accordance with the ERDF waste acceptance criteria document (BHI 2002a) and the *Supplemental Waste Acceptance Criteria for Bulk Shipment to the Environmental Restoration Disposal Facility*

(BHI 2005c) with specified criteria and procedures. Shipment of U.S. Department of Transportation hazardous materials will comply with Title 49 *Code of Federal Regulations* (CFR) or will require safety documentation demonstrating an equivalent degree of safety.

3.1.10 Assessment/Characterization and Waste Designation

Assessment consists of radiological surveys and sampling and preparation of all engineering and safety documents and subcontract documents to perform the field activities. Sampling of waste streams, both before and during remediation activities, to support worker health and safety and to support determination of final disposition of waste is performed in accordance with the SAP (DOE-RL 2005).

The extent of radiological contaminants will be monitored onsite using a combination of hand-held and fixed-mounted sodium iodide detectors. Additional alpha, beta, and gamma detectors may be used as determined by the project radiological engineer or the SAP. These detectors will be used to guide excavation in accordance with the observational approach to remediation. The contaminant data will be entered into appropriate databases and used for guiding remedial excavation, packaging the waste, adjusting waste profiles, updating MAR and FHC calculations, and providing backup data to support completion of waste tracking forms.

Chemical characterization data will be obtained by discrete samples of liquids, soil, and debris, if required, in accordance with the SAP with analysis provided by a contract laboratory. Laboratory results will be entered into a database to support remedial action site closeout decisions and contaminated waste disposal. Chemical field screening methods may be used and will follow the methods specified in the SAP. Details of the characterization requirements are described in the data quality objective report/SAP.

3.1.11 Decontamination

Decontamination will occur at the waste site or the survey station. If minor contamination is found on the outside of shipping containers at the survey station, the item will be decontaminated at the survey station. If major contamination is found, the container will be routed back through the waste site for decontamination. Following decontamination, the shipping container is then returned to the survey station to ensure that the outside of the container is free of removable contamination. Equipment and materials exiting waste site contamination areas or surface contamination areas may be decontaminated at the waste site.

3.1.12 Waste Transportation

The transport of contaminated material requires reusable containers to be filled at the remediation site, surveyed and decontaminated, if required, taken to a storage area, and then hauled to ERDF for unloading. Transportation will be performed in accordance with River Corridor Closure Contractor (RCCC) procedures and subcontract documents.

3.1.13 Closeout Sampling and Surveying

Closeout sampling and surveying will be conducted after all contaminated soil and debris has been removed from the 116-C-3 remediation area. The purpose of the closeout sampling is to provide a reasonable level of confidence that the remedial action goals have been met. The requisite amount of samples will be obtained based on the requirements specified in the SAP.

3.1.14 Demobilization

Two methods of demobilization can occur during the 116-C-3 Chemical Waste Tanks Remediation Project: (1) demobilization from the site before closeout (where closeout is defined as the completion of all stabilization activities, such that the site can be unmonitored) and (2) final site closeout followed by demobilization of the site.

Demobilization from the site (before closeout) typically consists of the following activities:

- Excavated materials that have previously been determined to be stable are configured to minimize releases of inventory (e.g., dry overpacked) and are staged on site. These activities will be ongoing during the remediation process.

- A crusting agent is applied to all soil surfaces and stockpiles to provide dust control during the period of inactivity.

Prior to closeout, the waste site will be evaluated by appropriate site and safety personnel to determine what activities/actions are required to place the site in a condition that meets any controls identified in the Safety Basis.

Activities involved with demobilization of a waste site after closeout will consist of decontaminating equipment, as well as those activities associated with the removal of fencing and boundary barriers.

3.1.15 Operational Systems

Water from existing mains is not potable (i.e., raw water) and, therefore, will be used only for fire protection, decontamination (as necessary), and dust suppression. The potable water supply is not at risk of contamination from the excavation site. Potable water is trucked to the site for sanitary use. Potable water is not used for dust suppression. The project has two raw water supply sources: (1) a water fill station in the 100 Area located near the river and (2) a water fill stations installed at the project.

The dust-suppression water trucks are filled from a raw water source through an air gap between the tank and the fill line. The water line also has a double-check valve to prevent any backflow into the system. The water truck may travel down haul roads within radiological buffer areas to spray the roads within the waste site. Upon exiting the radiological buffer area, the water truck will be surveyed for contamination. The dust-suppression water truck will be surveyed when leaving a radiological buffer area for contamination control, but will not be surveyed when leaving a radiological buffer area for dose control.

The project will have at least one dust-suppression water truck onsite to apply water. Water is applied where appropriate, using truck nozzles, sprinkler systems, and fire hoses. Pipes may be used to direct water flow on the site.

Crusting agents will be stored onsite. The agent will be mixed with water in the water trucks before application.

3.2 SAFETY-SIGNIFICANT SYSTEMS

The 116-C-3 Chemical Waste Tanks Remediation Project does not employ any safety-significant systems, structures, or components. This is consistent with the FHC of the facility as below Category 3 (radiological).

4.0 HAZARD AND ACCIDENT ANALYSIS

4.1 FINAL HAZARD CATEGORIZATION

Appendix C presents the details of the FHC.

The total inventory of the 116-C-3 tanks exceeds the DOE-STD-1027-92 Hazard Category 3 threshold (DOE 1997). The IHC is Hazard Category 3. In accordance with NS-1-2.1, "Hazard Categorization" (NS-1), an FHC and supporting hazard analysis must be prepared for any site or project that receives an IHC of Hazard Category 3 or above.

This section consists of the hazard analysis and the FHC for the 116-C-3 Chemical Waste Tanks Remediation Project. The process to develop FHCs and hazard analyses is fully described in NS-1-3.2, *Guide for Performing Hazard Analysis and Final Hazard Categorizations*. The hazard evaluation for the 116-C-3 Chemical Waste Tanks Remediation Project determined the FHC to be below Category 3 (sometimes referred to as "radiological") (BHI 2005b).

4.2 HAZARD IDENTIFICATION

The objective of the hazard identification process is to provide a basis from which to analyze the hazards associated with a facility (i.e., internal, external, natural phenomena, and common cause events) with the potential to adversely affect the public, workers, or the environment. To achieve this objective for the 116-C-3 remediation activities, the hazard identification process was used to address the following issues:

- Characteristics of the inventory of hazardous substances at the site
- Sources of energy inside the site capable of interacting with those inventories
- Sources of energy outside the site capable of interacting with those inventories
- Nonroutine hazards unique to the site.

Common industrial hazards were addressed only to the extent that they could lead or contribute to a release of hazardous substances. The hazard identification process builds on the inventory identification effort. The initial hazard categorization defined the total inventories of hazardous substances within the site. The hazard identification process characterizes the hazardous material inventories in terms of quantity, as a function of form and location within the site.

Prominent material forms at the 116-C-3 site include buried, partially buried, and exposed pipes and tanks; fixed and removable surface contamination on tank and piping services; residual liquids in pipes, tanks, and tank heel; chemical contaminants from dejacketing operations; and fuels and oils in vehicles.

This FHC assumes that any chemicals introduced to the waste site during remediation activities (e.g., stabilization) will be made of noncombustible materials.

4.2.1 Research

A document search was conducted for documents related to the waste site. Indices were reviewed and documents were inspected for pertinent information. Additional searches were conducted in various libraries and records holding areas of the information listed below:

- Declassified Document Retrieval System
- Historical operations documentation
- Construction drawings for the waste site
- Photographs
- Previous tank sampling documentation and analytical results.

Maps and engineering drawings references identified in the searches described above were reviewed by engineering staff to identify other potential information sources referenced therein. Pertinent references in the documents described above were obtained and reviewed as well.

The hazards identified during the hazard identification process (Appendix A, Table A-1) were generated from the above-referenced sources of information. These sources were used to identify the inventories of hazardous substances at the 116-C-3 waste site, as well as the types of energy sources that could impact these inventories. Other information sources included process knowledge, interviews with staff, and engineering judgment.

The depth of detail employed during the review of site-related documentation was considered sufficient to allow identification of the hazard controls necessary to provide adequate protection from hazards encountered during remediation of the site. This research also included a review of the following types of information:

- Remediation reports
- Hazard assessments
- Hazard screenings
- Hazard identification documents
- Criticality evaluations
- Previous DOE-approved safety analyses
- Hanford Site Waste Information Data System
- Remedial investigation/feasibility study reports or studies
- Waste remediation reports
- SAP (DOE-RL 2005)
- Excavation reports
- Closeout reports.

4.2.2 Inventory

Based on sampling and analysis data, the radiological inventory listed in Table 4-1 has been identified or assumed in the MAR for the contaminated soils and the 116-C-3 tank/piping liquids, sludges, steel (BHI 2005d).

Table 4-1. Radiological Inventory for the 116-C-3 Chemical Waste Tanks.

Radionuclide	Inventory (Ci)				
	Sludge	Liquid	Steel	Soil	Total
Am-241	4.1E-01	--	--	--	4.1E-01
C-14	3.0E-04	7.1E-04	2.4E-04	4.8E-04	1.7E-03
Co-60	2.1E-02	3.3E-04	1.1E-04	2.2E-04	2.2E-02
Cs-137	2.9E-01	1.1E+00	3.5E-01	7.1E-01	2.4E+00
Eu-152	2.8E-03	--	--	--	2.8E-03
Eu-154	3.3E-03	--	--	--	3.3E-03
H-3	7.6E-05	2.0E-03	6.7E-04	1.4E-03	4.1E-03
Ni-63	6.9E+00	--	--	--	6.9E+00
Pu-238	8.6E-03	--	--	--	8.6E-03
Pu-239/240	1.8E+00	--	--	--	1.8E+00
Pu-241[a]	1.8E+00	--	--	--	1.8E+00
Sr-90	7.6E+00	8.7E-02	2.9E-02	5.9E-02	7.8E+00
U-233/234	4.5E-03	1.2E-04	4.0E-05	8.1E-05	4.7E-03
U-238	4.6E-03	1.3E-04	4.3E-05	8.8E-05	4.8E-03
Y-90[b]	7.6E+00	8.7E-02	2.9E-02	5.9E-02	7.8E+00
Total	**2.6E+01**	**1.2E+00**	**4.1E-01**	**8.3E-01**	**2.9E+01**

NOTE: Inventory calculated in *Determination of Material at Risk (MAR) for 116-C-3,* 0100C-CA-N0011, Rev. 0 (BHI 2005d).

[a] Although not included in laboratory analyses, an inventory for plutonium-241 have been included above for sludge. Assuming weapons-grade plutonium and 45-year-old material, the inventory for plutonium-241 has been estimated to be equal to that of plutonium-239/240 (based on a plutonium-241:plutonium-239/240 ratio of 1 for the sludge material in the 116-C-3 tanks). Other isotopes (e.g., uranium-235) would also be expected; however, the inventories from such isotopes are considered negligible contributors to the sum-of-the ratios values.

[b] Yttrium-90 is assumed to be in secular equilibrium with its parent, strontium-90. Barium-137m is also in secular equilibrium with its parent, cesium-137, but because there are no EPA release values reported in *Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation and Liability Act: Radionuclides* (EPA 1989), this radionuclide was not included in the FHC calculations.

EPA = U.S. Environmental Protection Agency
FHC = final hazard categorization

4.2.3 Hazards Identified

The hazard evaluation results for the 116-C-3 remediation activities are summarized in Appendix A. The hazard types that could affect the inventory of hazardous substances associated with the 116-C-3 Chemical Waste Tanks are tabulated in Appendix A, Table A-1.

Each remediation project activity can be related to a set of generic hazards. The following hazard types were identified as being potentially associated with the 116-C-3 remediation project activities:

- Radiological material
- Fissionable material

- Toxic material (heavy metals)
- Carcinogens
- Biohazards
- Corrosive material
- Electrical hazards
- Potential/kinetic energy hazards
- Noise hazards
- Temperature extremes
- Asphyxiates
- Seismic
- Exposure to hazardous chemicals
- External exposure to ionizing radiation
- Internal uptake of radioactive material
- Explosive concentration of gases
- Fire/flammable materials
- Natural phenomena hazards.

A number of industrial hazards are associated with the remediation of any waste site. Many of these hazards are common to the non-nuclear industry, and their prevention and/or mitigation consists of standard industrial safety practices. The controls that will be used to manage these routine hazards are discussed in Section 5.2.

4.2.4 Hazards Summary

Following the hazards identification process, generic internal events and project activity-related events that could introduce energy sources to hazardous materials at risk (and thus result in a release of hazardous materials to the environment) were evaluated and documented in Appendix B, Table B-1. The hazard evaluation process for the 116-C-3 Chemical Waste Tanks Remediation Project is presented in Section 4.6.

4.3 HAZARD EVALUATION

A hazard evaluation workshop was held on May 10, 2005. A multidisciplinary team completed a systematic review of the potential hazards associated with the remediation activities.

The objectives of this process are as follows:

- Identify the events that could lead to releases of hazardous substances and which require additional quantitative analysis

- Rank these events based on potential consequences and frequency

- Identify engineered mitigative and preventative features that serve to control the hazard

- Identify the commitments and administrative controls necessary to manage the hazard.

This section evaluates the potential interactions of the hazards identified in Appendix A and the project activities described in Section 3.1 that could result in potential consequences to workers or the environment.

4.3.1 Hazard Evaluation Summary

The hazards evaluated in this section originated from the hazard identification process discussed in Appendix A. To this end, the hazard evaluation process involved a facilitated meeting with the following types of personnel:

- Experienced safety analysts
- Fire protection professionals
- Nuclear criticality specialists
- Radiation control and industrial hygiene professionals
- Design engineering personnel
- Field engineers and superintendents.

The hazard evaluation considered a broad range of events. Many of these events have negligible or low consequences and are adequately managed with the programmatic controls identified in Section 5.2. These events do not require detailed treatment in the FHC document. Also, although certain events considered in the evaluation process potentially have significant consequences, the probability of some of the events actually occurring is beyond extremely unlikely (i.e., any event with a frequency of 1 x 10^{-6}/yr or less). These events also do not require detailed treatment in the FHC document.

The results of the hazard evaluation are presented in Appendix B, Table B-6. These hazards were identified as having the greatest potential consequences (i.e., greatest impact to the MAR at the 116-C-3 remediation site). The bounding hazards were identified as requiring detailed hazard analysis.

4.3.2 Applicable Activities, Exposures, and Controls

This section presents detailed hazard evaluations for the hazards that were identified in Appendix B, Table B-1 as being the bounding unmitigated release. This section also identifies any activities that would be bounded by the consequences of these bounding accident scenarios and identifies the controls that are applicable to the bounding accident scenarios. These controls are categorized as follows:

- Special controls. These controls are required to maintain the assumptions used to determine the FHC

- Project-specific controls. These controls are established to protect the workers for the specific accident under consideration and arise from the hazard evaluation process (e.g., emergency response instructions and material-handling restrictions).

- Programmatic controls. These controls are institutional controls established for worker protection that apply to the activity under consideration (e.g., elements of the radiation control program, rigging procedures, and training requirements).

Appendix B, Table B-6 identifies several hazardous events that could lead to releases from the 116-C-3 remediation activities (e.g., natural phenomena, impact from excavation equipment). Such events could lead to releases as a result of high winds, dumping materials, wind entrainment from exposed materials, and initiation of a fire causing heating of contaminated materials. The following subsections discuss the impacts of these release mechanisms on the materials from the 116-C-3 remediation activities and assess the respirable airborne release fractions (ARFs).

Modified ARFs were used to adjust DOE-STD-1027 Category 3 TQs for each of the following accident scenarios by multiplying tabled TQ values in DOE-STD-1027 by the ARF value used to determine the original tabled TQ value, and dividing by the ARF appropriate for the specified accident scenario.

Dust mitigation measures (dust suppression) will be used. The soil that is to be processed during remediation of the 116-C-3 Chemical Waste Tanks may also require application of dust suppression prior to placement in containers before shipment to ERDF. These containers use protective tarps to limit the amount of contaminated soil that could be released to the environment.

4.4 BOUNDING ACCIDENT SCENARIOS AND CONSEQUENCES

4.4.1 Dumping

Contaminated Soil or Stabilized Material: Dumping/spilling of soil/solidified contents could be initiated by several mechanisms: (1) operator loss of control of an excavator bucket during the loadout of the soil/pulverized solidified matrix or (2) spilling and resuspension of solidified material during tank-shearing operations. The respirable ARF for dumping/spilling used in Roberson (2002) Attachment 4 is 1.0E-06. Therefore, the respirable release fraction (R value) used for dumping or spilling of contaminated soil is 1.0E-06.

Contaminated Combustible Solids: Contaminated combustible solids expected to be present during remediation activities of the 116-C-3 Chemical Waste Tanks are limited to used personal protective equipment (PPE), which may be stored in drums near the waste site. Used PPE will have minimal contamination and is made of very lightweight materials. Consequently, the PPE would generate little force during impact with surfaces. DOE (2000), Section 5.2.3.1, states that no significant suspension of surface contamination is postulated for such materials. Therefore, dumping of contaminated combustible solids is not considered further in this calculation.

Contaminated Noncombustible Solids: Contaminated noncombustible solids (e.g., piping) will be excavated from the waste site during remediation activities. The solids may be lifted out of the excavation and dropped, resulting in a release of surface contamination. Only those contaminated particles that are loose (i.e., not combined with the surface matrix) on the surface of the noncombustible solids would be subject to release. The majority of the surface contamination on noncombustible solids is expected to be in the form of a scale that is strongly adhered to the solid (i.e., pipe, tank) surface. DOE (2000), Section 5.3.3, addresses free-fall spill and impaction stress to such solids. The bounding R value for shock vibration of contaminated noncombustible materials that do not undergo brittle fracture is 1.0E-03.

Contaminated Liquid/Sludge: The potential exists for liquid/sludge to be inadvertently released during solidification operations due to a loss of tank integrity from corrosion. Section 3.2.3.2 of DOE (2000) indicates a spill of aqueous solutions (i.e., slurries), at a 3-m fall distance, has a bounding R value of 4.0E-05.

4.4.2 High-Wind Entrainment

Contaminated Soil: Because carbon steel is stable at a high pH and a significant amount of liquid remains in the south tank, it is believed that the tank has not leaked. However, for conservatism, it is assumed that the tank has leaked and contaminated a 0.3-m-thick layer of soil equal to the footprint of the tank (10.9 m in length by 3.5 m in diameter) or 12.3 m^3 of contaminated soil. The soil entrainment rate used in Attachment 4 of Roberson (2002) is 4.0E-03 g/m^2-h, or 3.2E-02 g/m^2-8h. (Note: An 8-hour exposure is selected consistent with DOE-STD-3009-94, Appendix A, Section A.3.3.)

Equation 1 was used to calculate the entrainment R value of 6.3E-08 for this scenario.

$$R = ARF \times RF = [(SER)(SA)(T)]/[(p)(SV)] \qquad (1)$$

where:

SER = soil entrainment rate obtained from Attachment 4 of Roberson (2002), 4.0E-03 g/m^2-h
SA = surface area of contaminated soil = 40.3 m^2
T = time interval over which soil is exposed to wind (8 hours)
p = assumed soil density of 1.7g/cm^3 or 1.7E+06 g/m^3
SV = contaminated soil volume = 12.1 m^3.

Contaminated Combustible Solids: The 116-C-3 waste site contains no contaminated combustible solids. Contaminated combustible solids would, in all likelihood, be limited to used PPE contained in drums. The amount of contamination present on used PPE is anticipated to be minimal. A high-wind event could resuspend freshly deposited surface contamination, but the bulk of the waste will be protected from high winds by the waste drum. Section 5.2.4 of DOE (2000) indicates that the bounding R value for this waste form is 4E-5/hr, or 3.2E-04 for an 8-hour duration.

Contaminated Noncombustible Solids: Only loose contamination on the surfaces of noncombustible solids would be available for entrainment by high winds (i.e., not combined with or embedded in the surface matrix). The majority of the surface contamination, on noncombustible solids, is expected to be in the form of a scale that, in all probability, is strongly affixed to the pipe or tank surfaces. The inventory in this form, potentially subjected to high wind entrainment, is anticipated to be minimal. Section 5.3.4 of DOE (2000) indicates that the bounding R value for the entrainment of a sparse population of loose surface contamination from a noncombustible surface is 4E-5/hr, or 3.2E-04 for an 8-hour duration. (Note: An 8-hour exposure is selected consistent with DOE-STD-3009-94, Appendix A, Section A.3.3.)

Contaminated Liquid/Sludge: Liquid/sludge inadvertently released from the waste tanks may be entrained by wind during solidification activities. Liquid/sludge or solidified material remaining in the tanks is protected from entrainment by wind. Section 3.2.4.5 of DOE (2000) indicates that the bounding R value for an outdoor pool at low wind speeds is 4E-7/hr, or

3.2E-06 for an 8-hour duration. (Note: An 8-hr exposure is selected consistent with DOE-STD-3009-94, Appendix A, Section A.3.3.)

4.4.3 Explosion (Flammable Gas/Air Mixture Deflagration)

Contaminated Solidified Matrix: The pressure rise generated by a flammable gas/air mixture deflagration during remediation activities could cause a resuspension of contaminated partially solidified or fragmented material from within the tank. However, large amounts of fuel (hundreds of pounds or more) are generally required for a flammable gas/air mixture to form an unconfined cloud within the fuel's flammable limits that then subsequently explodes. Such amounts of fuel will not be present during remediation activities. The tanks could potentially serve as a confining space for a flammable gas/air mixture, but they are vented to atmosphere. If a deflagration were to occur within a tank, a small amount of contaminated, partially solidified material could be resuspended. Section 4.3.2.2 of DOE (2000) states that pressure impulses generated by an explosive event that may entrain and hurl aggregate materials will not result in significant airborne releases unless aggregate materials are hurled at considerable velocities. It is estimated that the contaminated material that could be resuspended is negligible; therefore, contaminated solidified matrix materials are not considered further in this calculation.

Contaminated Combustible Solids: Contaminated combustible solids expected to be present during remediation activities of the 116-C-3 tanks are limited to used PPE, which may be stored in drums near the waste site. Used PPE will have minimal contamination and does not provide a rigid surface for pressurized gases to act upon. DOE (2000), Section 5.2.2.3, states that the bounding R value for this scenario is 1E-3.

Contaminated Noncombustible Solids: Small amounts of contaminated noncombustible solids, such as piping, will be exposed during remediation activities. The majority of the surface contamination on noncombustible solids is expected to be in the form of a scale that is strongly affixed to the pipe or tank surfaces. Section 5.3.2.3 of DOE (2000) indicates that the bounding R value for the release of pressurized gases over contaminated, noncombustible materials is 2E-03.

Contaminated Liquid/Sludge: It is possible that a deflagration could occur within a tank during solidification activities. However, because the amount of flammable gases will be relatively small and the tanks are vented to atmosphere, the potential damage is anticipated to be low. It is believed that most of the partially solidified liquid/sludge or solidified material in the tanks would not be affected by a deflagration in the headspace. Section 3.2.2.3.2 of DOE (2000) indicates that the bounding R value for an overall vessel failure would be 4E-5. Given that the waste site consists of tanks that will be mostly underground throughout remediation activities, it is believed that this value is very conservative.

4.4.4 Vehicle/Excavator Impact

Contaminated Soil/Pulverized Solidified Matrix: A vehicle or excavator impact to contaminated soil or the contaminated soil pulverized solidified matrix could result in resuspension of the material. However, only a small fraction of the potentially contaminated volume could be affected. Section 4.4.3.3.2 of DOE (2000) is not directly applicable to this scenario due to the physical differences between the experimental conditions (powder placed on a plywood sheet or in a quart can within a vented metal box) and the tank remediation activities, but it does provide a reference point. The bounding R value in Section 4.4.3.3.2 of DOE (2000) is 2E-3.

Contaminated Combustible Solids: Contaminated combustible solids expected to be present during remediation activities of the 116-C-3 tanks are limited to used PPE, which may be stored in drums near the waste site. Used PPE will have minimal contamination. Vehicle/equipment impact to packaged contaminated PPE could result in a failure of the drum and suspension of surface contamination. Section 5.2.3.2 of DOE (2000) states that the bounding R value for this scenario is 1E-4.

Contaminated Noncombustible Solids: Contaminated noncombustible solids, such as piping, will be exposed during remediation activities. Contaminated particles adhering to the surface of the noncombustible solids would be subject to release by impact due to the resultant flexing of the solid. The majority of the surface contamination on noncombustible solids is expected to be in the form of a scale that is strongly affixed to the pipe or tank surfaces, and most of this will, in turn, be protected from impact by at least 0.6 m (2 ft) of soil. Section 5.3.3.2.2 of DOE (2000) indicates that the bounding R value for impact to contaminated noncombustible materials that do not brittle fracture is 2E-03.

Contaminated Liquid/Sludge: It is possible that an impact to a tank could occur during solidification activities. However, because the bulk of the tanks will remain underground, any impact is expected to be limited to the top section of a tank. It is expected that most of the unsolidified liquid/sludge or solidified liquid/sludge in the tanks would not be affected by an impact. Section 3.2.2.3.2 of DOE (2000) indicates that the bounding R value for an overall vessel failure would be 4E-5. Given that overall vessel failure would probably not occur as a result of an impact, it is believed that this value is very conservative.

4.4.5 Fire

Contaminated Soil or Solidification Matrix: The area surrounding the 116-C-3 site consists of cobbles without significant amounts of vegetation. The contaminated soil or contaminated solidification matrix associated with the 116-C-3 remediation is noncombustible. Fire is judged to result in an insignificant release.

Contaminated Combustible Solids: Combustible solids expected to be present during remediation activities of the 116-C-3 tanks are limited to used PPE, which may be stored in drums near the waste site. PPE will have minimal amounts of contamination. Section 5.2.1.1 of DOE (2000) indicates that the bounding R value for packaged contaminated combustible materials that are heated/burned is 5E-04. This value was judged to be bounding for conditions under consideration (e.g., ignition of the soft waste from an external source such as a range fire or an internal source such as a vehicle fire).

Contaminated Noncombustible Solids: A fire could eject some of the contamination from the metal tank or pipe surfaces due to flexing of the solid surface. Tanks, piping, structural components, concrete, underground transfer lines, etc., will be size reduced utilizing cutting torches, hydraulic shears, grinders, snippers, wire saws, or by mechanical disassembly, as applicable. Section 5.3.1 of DOE (2000) indicates that the bounding R value for this event is 6E-05. It is expected that only a small fraction of the total inventory would be subject to release by this mechanism.

Contaminated Liquid/Sludge: A potential initiator of an onsite fire could be ignition of gasoline or diesel from the excavator. It is possible for the piping/tanks to be heated by a fire and, as a result, the unsolidified liquid/sludge contents could also be heated. It is anticipated that the energy input from a worst-case fire would be insufficient to result in boiling of the liquids. Section 3.2.1.1 of DOE (2000) indicates that the bounding R value for heating of shallow pools of aqueous solutions is 3E-05, which is based on experiments involving ml volumes of solution in a shallow steel dish. While this is not directly applicable to the situation of heating 34,800 L (9,193 gal) of liquid/sludge, it does provide a reference point. The R value for heating of the liquid/sludge would be expected to be significantly less than 3E-05.

4.4.6 Summary of Release Values

The results of the assessment of respirable ARFs from the 116-C-3 remediation activities are summarized in Table 4-2. The bounding value for each material form is the largest R value (ARF x RF) for any of the release mechanisms.

Table 4-2. Assessment of Results of Respirable Airborne Release Fractions.

Material Form	Release Mechanism					Bounding Value
	Dumping	Entrainment[a]	Deflagration	Vehicle Impact	Fire	
Soil/scale/ soldification matrix	1E-6	2E-7	<<2E-3	<<2E-3	Negligible	1E-6
Liquid/sludge	4E-5	3.0E-6	4E-5	<4E-5	<<3E-5	**4E-5**
Contaminated combustibles	Negligible	3.0E-4	1E-3	1E-4	5E-4	1E-3
Contaminated noncombustibles	1E-3	3.0E-4	2E-3	2E-3	6E-5	2E-3

[a] Entrainment rates based on an 8-hour duration.

Nearly all of the radiological inventory associated with the 116-C-3 Chemical Storage Tanks is expected to be in the form of contaminated liquid/sludge contained within the tanks solidified or unsolidified, depending on the remediation stage. The inventory associated with the other two waste forms (combustible and noncombustible) is expected to be orders of magnitude less. Based on the bounding R value determined for each waste form and the potential radiological inventory associated with each form, it is believed that a bounding R value of 4E-5, as determined for liquid/sludge, is a reasonably conservative value to apply to the entire inventory of the tanks for FHC purposes. It is recognized that some events, particularly those involving contaminated combustibles and contaminated noncombustibles, can produce higher values. Conversely, some events involving contaminated soil would produce smaller values. However, the higher release events would only affect a small fraction of the total inventory.

4.5 NUCLEAR CRITICALITY ASSESSMENT

A criticality screening for the 116-C-3 remediation activities has been completed and is documented in *Remediation of the 116-C-3 Underground Sludge Tanks*, Criticality Evaluation No. 0100C-CE-N0005, latest revision (see BHI 2004a for Rev. 0). The fissile isotopes listed for this site did not (either individually or as sum-of-the-ratios) exceed the subcritical activity threshold limits of NS-1-2.2, "Criticality Safety Reviews." The evaluation concluded that neither criticality limits nor controls were needed, and that there are no normal or credible abnormal conditions that could lead to an uncontrolled nuclear event (criticality).

4.6 FINAL HAZARD CATEGORIZATION

The hazards evaluated in the FHC calculation are identified in Section 4.4. The bounding accident scenario analyzed for this site is a dumping or deflagration scenario with an R value of 4E-05. Fire events and seismic events are assumed to have no impact on the contaminated soil or the solidified material. The FHC calculations are summarized below. See Appendix C for calculation details.

Only radionuclides were used in determining the FHC because there are no other hazardous materials that exceed the 29 CFR 1910 or 40 CFR 68 TQs; therefore, analysis of chemical constituents was not included in the FHC calculation. The hazard Category 3 TQs in DOE-STD-1027-92 (DOE 1997) are based on the release values (RV) calculated in EPA (1989). Release values are determined for each of four exposure pathways: food ingestion, water ingestion, inhalation, and direct exposure. The TQ for a given isotope is 20 times the most restrictive RV. The TQ can be expressed as:

$$Q = 20 \times \mathrm{MIN} \{ RV_{FOOD}, RV_{WATER}, RV_{INH}, RV_{DIR} \}$$

The EPA methodology uses the following assumptions:

1. The RV for the water ingestion pathway assumes that 100% of the material is released to drinking water (see EPA 1989, Appendix B.1)

2. The RV for the inhalation pathway and the RV for the food ingestion pathway both are inversely proportional to a respirable airborne release fraction (see EPA 1989, Appendices A.2 and C.1).

3. The RV for direct exposure for isotopes other than noble gases assumes a point source.

The DOE Office of Nuclear and Facility Safety Policy Nuclear Safety Technical Position, NSTP 2002-2 (DOE 2002), allows that the hazard Category 3 TQs for radionuclides for which the food pathway and the inhalation pathway are limiting may be revised if, based on the physical and chemical form and available dispersive energy sources for the facility and its hazardous materials, the credible release fractions (airborne release fractions) can be shown to be significantly different from the values used in the EPA Technical Background Document (EPA 1989). All potential accident scenarios must be considered under unmitigated conditions. All pathways must be considered and the most limiting pathway must be used.

Based on the guidance in NSTP 2002-2 (DOE 2002), the adjusted Category 3 TQ for an isotope in a particular material form can be expressed as shown in equation 2:

$$TQ_{ADJ} = 20 \times \mathrm{MIN} \{ f_1 \times RV_{FOOD}, f_2 \times RV_{WATER}, f_1 \times RV_{INH}, f_3 \times RV_{DIR} \} \qquad (2)$$

where:

f_1	=	the ratio of the respirable airborne release fraction used in the EPA analysis (from EPA 1989, Exhibit A-1) to the largest respirable airborne release fraction from any potential accident
RV_{FOOD}	=	the release value for the food pathway from EPA (1989), Appendix E
f_2	=	the ratio of the fraction of material released to drinking water in the EPA analysis (i.e., 1) to the largest fraction of material released to drinking water in any potential accident scenario
RV_{WATER}	=	the release value for the water pathway from EPA (1989), Appendix E
RV_{INH}	=	the release value for the inhalation pathway from EPA (1989), Appendix E
f_3	=	the ratio of the dose rate from a point source at 30 m to the dose rate from a distributed source of equal activity at 30 m
RV_{DIR}	=	the release value for the direct exposure pathway from EPA (1989), Appendix E.

The potential accident scenarios and corresponding release fractions are identified from a hazard analysis. This FHC will be based on the hazard analysis in Appendix B and the scenario analyses presented in Appendix C. These analyses form the basis for identifying appropriate respirable airborne release fractions. Equation 2 was used to generate adjusted TQs for each constituent present at the burial ground.

The inventories for each constituent were divided by the adjusted TQ values. These individual ratios were then summed and compared to 1. If the sum of the ratios was above 1, using the adjusted TQ, then the adjusted TQ has been exceeded and the FHC for the waste site is determined to be Category 3. If the sum of the ratios is below 1, the FHC is determined to be below Category 3.

Using the adjusted TQ values as described above, the final sum-of-the-ratios for the 116-C-3 Chemical Waste Tanks is identified in Table 4-3. The sum-of-the ratios for this site is below 1; therefore, the FHC for this site is below Category 3 (radiological).

Table 4-3. Maximum Sum-of-the-Ratios.

Isotope	Material at Risk (Ci)[a]	1027 Category 3		
		$TQ_{ORIGINAL}$ (Ci)[b]	$TQ_{REVISED}$ (Ci)[c]	Ratio
Am-241	4.1E-01	5.2E-01	1.3E+01	3.2E-02
C-14	1.7E-03	4.2E+02	3.0E+03	5.8E-07
Co-60	2.2E-02	2.8E+02	2.8E+02	7.8E-05
Cs-137	2.4E+00	6.0E+01	1.3E+03	1.9E-03
Eu-152	2.8E-03	2.0E+02	7.0E+02	4.0E-06
Eu-154	3.3E-03	2.0E+02	8.4E+02	3.9E-06
H-3	4.1E-03	1.6E+04	1.2E+05	3.5E-08
Ni-63	6.9E+00	5.4E+03	1.4E+06	5.1E-06
Pu-238	8.6E-03	6.2E-01	1.6E+01	5.6E-04
Pu-239/240	1.8E+00	5.2E-01	1.3E+01	1.4E-01
Pu-241	1.8E+00	3.2E+01	8.0E+02	2.2E-03
Sr-90	7.8E+00	1.6E+01	4.1E+03	1.9E-03
U-233/234	4.7E-03	4.2E+00	1.1E+02	4.5E-05
U-238	4.8E-03	4.2E+00	1.1E+02	4.6E-05
Y-90[d]	7.8E+00	1.4E+03	3.6E+05	2.2E-05
			Sum of Ratios:	**1.7E-01**

[a] MAR was obtained from *Determination of Material at Risk (MAR) for 116-C-3*, 0100C-CA-N0011, Rev. 0 (BHI 2005d).
[b] Original TQ value is from DOE-STD-1027.
[c] Revised TQ values obtained from the FHC presented in Appendix C using bounding release fraction of 4E-05.
[d] Yttrium-90 is assumed to be secular equilibrium with its parent strontium-90. Barium-137m is also in secular equilibrium with its parent cesium-137, but because there are no EPA release values reported in *Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation and Liability Act: Radionuclides* (EPA 1989), this radionuclide was not included in the FHC calculation.

EPA = U.S. Environmental Protection Agency
FHC = final hazard categorization
MAR = material at risk
TQ = threshold quantity

5.0 CONTROLS AND COMMITMENTS

Special controls are derived from the assumptions made in the FHC that are required to ensure that the FHC remains valid. These controls will be incorporated into the appropriate work implementing instructions developed for the project. The controls identified in this document will be in place throughout the entire remediation process, as applicable.

The special controls for the remediation efforts pertaining to 116-C-3 are as follows:

1. The waste forms encountered at this site are limited to liquids/sludges, solidified liquid/sludge, contaminated tank and pipe surfaces, contaminated combustibles (e.g., PPE), concrete, and contaminated soil.

2. The bulk ($\geq$ 90%) of the inventory (i.e., activity) is in the form of contaminated liquid/sludge, steel, and soil.

3. The total inventory is less than or equal to the inventory assumed in the analysis as documented in the FHC presented in Appendix C.

If any condition listed below is encountered, the situation will be treated as a discovery under the FHC evaluation process as described in Section 1.4:

- Waste forms found that are different than those as identified above
- Total inventory is determined to be more than what was assumed
- Less than 90% of the inventory (i.e., activity) is in the form of liquid/sludge, steel, and soil.

5.1 PROJECT-SPECIFIC CONTROLS

Project-specific controls are established for the protection of workers that apply specifically to the activity under consideration. These controls are derived from the hazard evaluation and engineering judgment. These controls will be flowed down into the appropriate work implementing instructions developed for the project. Based on the hazard evaluation, the following project-specific controls have been identified:

- In the event of a windstorm or an emergency at a co-located facility occurring during remediation activities, worker safety will take precedence over all remediation activities and workers will be evacuated from the site.

- Dust suppressants/fixative will be used, as appropriate.

- Appropriate workplace air monitoring will be performed and health and safety controls implemented, as specified in the SS HASP, RWP, site-specific instructions, or any other approved document.

5.2 PROGRAMMATIC CONTROLS

5.2.1 Conduct of Operations

Conduct of Operations is imposed to ensure that work is performed in a controlled and organized manner, that all facets of remediation activities have been considered, and that the necessary documentation is maintained.

Conduct of Operations strongly emphasizes technical competency, workplace discipline, and personal accountability to ensure a high level of performance during all activities. If conflict arises between instructions or directions, work shall be safely stopped until resolution is achieved. Safety is the first priority, and all planning shall include appropriate safety analyses to identify potential safety and health hazards and the methods needed to appropriately control these hazards. Workers will not start work until approved safety procedures, instructions, and directions are provided for nonroutine operations.

Conduct of Operations requires workers to be alert and aware of conditions affecting the job site. Operators and workers conducting field activities should be notified of changes in the work area status, abnormalities, and difficulties encountered in performing project operations. Similarly, operators and workers shall notify the chain of command of any unexpected situations. In accordance with the severity of a finding (i.e., emergency condition), notification requirements will be expanded to include upper tier management and regulatory agencies.

5.2.2 Training

The WCH Environmental Safety and Health Training Program provides workers with the knowledge and skills necessary to safely execute assigned duties. A graded approach is used to ensure that workers receive a level of training commensurate with their responsibilities in accordance with applicable requirements.

Formal and informal safety and health training and education are essential to help employees recognize the hazards of their jobs. Particular emphasis is placed on understanding hazards associated with jobs and the potential effects on employees; ensuring that employees follow rules, procedures, and work practices; and that employees know how to respond to an emergency. Training and education programs are maintained current to ensure that both management and employees understand and recognize the hazards to which they are exposed.

Employees receive both formal and informal training. Formal training includes Hanford General Employee Training, New Hire Orientation, project-specific training, and on-the-job training. The Hazardous Material Management and Emergency Response (HAMMER) training facility provides numerous training and education opportunities for WCH employees. Mockup training is also used in preparation for conducting potentially high-hazard activities.

Safety of operators and crane operations is enhanced by operator training (only trained and qualified operators that meet the subcontractors safety plan and training requirements are allowed to operate heavy equipment and cranes) and periodic maintenance and inspection of the heavy equipment and cranes in accordance with the site safety plan and procedures. The specific training requirements for subcontractors performing hoisting and rigging on construction projects is outlined in Submittal 0100B-SC-G0012-5-27-01B, Exhibit G, Section II, *Construction Safety & Health Requirements, Subsection CR-06, Hoisting and Rigging*.

Radiological control technicians must complete and be current in radiological control technician qualification training. These training courses require the successful completion of examinations to demonstrate understanding of theoretical and practical classroom material.

Specialized training will be provided, as needed, to instruct workers in the use of nonstandard equipment, in the performance of abnormal operations, Safety Basis controls, and in the hazards of specific activities. Specialized training may be provided by on-the-job training activities, by classroom instruction and testing, or by pre-job briefings. The depth of training in any discipline will be commensurate with the degree of hazard involved and the knowledge required for task performance.

Some site remediation project activities will require the acquisition of expert services, as opposed to project staff training.

In addition to fundamental training, managers, supervisors, and team leads are provided with the WCH Supervisor Development Program.

Line managers, supervisors, team leads, and facility personnel participate in facility drills, investigations, and critiques. Information from the critiques is shared with employees to improve emergency response. Additional training is also provided for the building emergency directors and facility emergency response personnel.

Because of the nature of activities conducted at the 116-C-3 Chemical Waste Tanks Remediation Project, various administrative controls will be implemented to ensure that only individuals with the appropriate training and authorization are allowed access within the site. Personnel who have unescorted access to the 116-C-3 site must meet special training requirements (i.e., 24-Hour Hazardous Worker Training, Radiological Worker II training, pre-job briefing, and required site and activity-specific reading). These training requirements provide adequate assurance of worker safety.

5.2.3 Configuration Control

Established configuration/change control processes ensure that proposed changes are reviewed in relation to the specified commitments. If discovery indicates a breach of these commitments, work will cease so that stabilization and/or recovery actions may be identified and implemented, as appropriate. WCH off-normal event procedures describe the reporting process and protocol applicable to such a discovery. NS-1-2.1 defines the FHC evaluation process and requirements for facilities that have a FHC of below category 3.

5.2.4 Quality Assurance

The WCH Quality Assurance Program Description (QAPD) (WCH, 2006a) is written to comply with the requirements of DOE 0 41 4.1B, Quality Assurance; Title 10 CFR 830, Subpart A, "Quality Assurance Requirements"; and the quality assurance requirements of the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement). Both the referenced DOE Order and the CFR comprise 10 quality criteria that must be met. Additional or specific requirements originating from the Tri-Party Agreement are annotated as such. Consideration was also given to DOE G 414.1-2, Quality Assurance Management System Guide, in the preparation of the QAPD.

5.2.5 Occupational Safety and Industrial Hygiene

Remediation activities at the 116-C-3 waste site will be controlled by the SS HASP, as required by established WCH procedures. A HASP will be written for the 116-C-3 Chemical Waste Tanks Remediation Project to address the health and safety hazards of each phase of site operation and will include the requirements of a site HASP for hazardous waste operations and/or construction activities, as specified in 29 CFR 1910.120.

Before work begins, a pre-job briefing is held with the affected workers. This briefing will include reviews of the hazards that may be encountered and the associated requirements. Throughout an activity, daily briefings may also be held, as well as special briefings before major evolutions. Potentially significant nonradiological hazards expected during the 116-C-3 Chemical Waste Tanks Remediation Project might include the following:

- Asbestos exposure
- Carcinogen exposure
- Exposure to biological hazards (insect and snake bites)
- Exposure to corrosive materials
- Exposure to hazardous chemicals
- Exposure to reactive materials
- Exposure to temperature extremes
- Flammability hazards
- Hot work, if required
- Kinetic energy hazards (e.g., working in close proximity to moving equipment)
- Lead exposure
- Noise
- Polychlorinated biphenyl exposure
- Possible exposure to organic and inorganic chemicals
- Soil slope instability
- Toxic material exposure
- Uneven working surfaces
- Working at heights
- Working in close proximity to moving equipment
- Working in confined and subgrade spaces.

5.2.6 Emergency Management

The WCH Emergency Management Program (including preparedness, planning, and response) is described in detail in SEM-2, *Emergency Management Program,* and contains the administrative responsibilities for compliance with the *Hanford Emergency Management Plan* (DOE-RL 1999). The 116-C-3 Chemical Tanks Remediation Project will be managed under the Operational Emergency Base Program.

All emergency planning and preparedness activities for the 116-C-3 Chemical Waste Tanks Remediation Project will be consistent with planning and preparedness actions undertaken by other Hanford Site contractors and similar projects. Activities will be in a manner that ensures the health and safety of workers and the public and the protection of the environment in the event of an abnormal incident or emergency at the 116-C-3 Chemical Waste Tanks.

Project response to any emergencies (i.e., project or neighboring project incident) will be to evacuate personnel to a safe location and initiate the required responsibilities of the Building Warden and other project personnel in support of the Incident Command System.

The WCH Emergency Management Program is based on a graded approach and is commensurate with the hazards and consequences associated with the projects/facilities and activities managed by WCH (involving radioactive and nonradioactive hazardous materials) and/or neighboring facilities.

5.2.7 Radiological Control Program

The Radiological Control and Protection Program is defined in DOE-approved programs and WCH-approved procedures. This program implements WCH policy to maintain radiological exposures to levels that are as low as reasonably achievable (ALARA) and to ensure adequate protection of workers. The WCH Radiological Protection Program meets the requirements of 10 CFR 835. Radiological material handling will be managed in accordance with *WCH Radiological Control* Manual (RCM) (WCH 2006b), RC-1, and RC-100 through RC-300. Appropriate dosimetry, radiation work permits, PPE, ALARA planning, periodic surveys, and Radiological Control (RadCon) technical support will be provided.

The RCM provides guidance at the WCH and subcontractor management level for compliance with the requirements of 10 CFR 835, DOE orders, contractual requirements, and management-directed radiological actions.

The RCM is intended to ensure that unnecessary, unplanned, and accidental radiation exposures are avoided, and individual and collective radiation exposure to workers and the general population and the release of radioactive material to the environment are maintained ALARA. The scope of the RCM is limited to occupational radiation protection. Environmental radiation protection is beyond the scope of the RCM. The plans, programs, schedules, and all WCH activities shall be in compliance with 10 CFR 835 as specified in the approved WCH Radiation Protection Program (BHI 2000).

Site-specific radiological controls in the form of the technical assessment, RWP, and environmental radiological task instruction will be adhered to during remediation activities.

The ALARA planning process will identify shielding requirements, contamination control requirements (including local ventilation controls, if applicable), radiation monitoring requirements, and other RadCon requirements for the individual tasks conducted during the course of the 116-C-3 Chemical Waste Tanks Remediation Project.

5.2.8 Hazardous Material Control

The WCH Hazardous Material Control Program is addressed at both the programmatic level and at the site-specific level. The WCH Safety and Health Program manual, SH-1, is the top-tier safety and health document that establishes requirements and provides guidelines to minimize health and safety risks to workers and the public. The program-level manual and implementing procedures contained in SH-1, *Safety and Health* , are intended to ensure that all elements of a health and safety program for hazardous waste operations are met.

Hazardous waste sites are evaluated to identify site-specific hazards, including identification of hazardous materials, and to determine the appropriate health and safety control procedures needed to protect employees from identified hazards in accordance with 29 CFR 1910.120[c] and 29 CFR 1926.65(c).

Appropriate site control procedures are developed during the planning stages of hazardous waste cleanup operations to control employee exposure to hazardous substances. These procedures shall be modified as necessary when new information becomes available in accordance with 29 CFR 1910.120(d) and 29 CFR 1926.65(d).

The WCH shall institute engineering controls and work practices to reduce and maintain employee exposure ALARA below the permissible exposure limits (PELs) for substances regulated by 29 CFR 1910 (to the extent required by Subpart Z) or the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs), whichever is more protective, except when such controls and practices are not feasible. Controls and work practices are described in RC-200 and SH-1 (see RC-1-10.2, "ALARA Program Description").

Whenever engineering controls and work practices are not feasible or are not required, any reasonable combination of engineering controls, work practices, and PPE shall be used to reduce and maintain employee exposures to levels at or below the OSHA PEL for substances regulated by 29 CFR 1910 (to the extent required by Subpart Z) or the ACGIH TLVs, whichever is more protective. (see 29 CFR 1910.120[g] and 29 CFR 1926.65[g]).

Monitoring shall be performed in accordance with 29 CFR 1910.120(h), 29 CFR 1926.65(h), RC-200, and SH-1, Section 4.0, *Industrial Hygiene*, where there may be a question of employee exposure to hazardous concentrations of hazardous material. Monitoring shall be performed to verify the proper selection of engineering controls, work practices, and PPE so that employees are not exposed to levels that exceed the OSHA PEL or ACGIH TLV (or published exposure levels, if there are no assigned PELs or TLVs for the substance) (see 29 CFR 1910.120[h] and 29 CFR 1926.65[h]).

The WCH shall ensure that employees, contractors, and subcontractors (or their representative[s]) engaged in hazardous waste operations are informed of the nature, level, and degree of exposure that is likely as a result of participation in such hazardous waste operations.

Hazardous materials requiring specialized controls (e.g., materials contaminated with lead, beryllium, cadmium) will be handled in accordance with PAS-1, *Project Activities and Support*, PAS-2, *Integrated Work Control Program*, and SH-1, Section 4, *Industrial Hygiene*, which address their unique hazards and regulatory requirements. Hazardous substances, contaminated liquids, and other residues shall be handled, transported, labeled, and disposed of in accordance with 29 CFR 1910.120(j); 29 CFR 1926.65(j); WMT-1, Section 1.0, *Waste Management*; and WMT-1, Section 2.0, *Transportation*.

5.2.9 Fire Protection

WCH and its subcontractors are committed to support a level of fire protection and fire-suppression capabilities that are sufficient to minimize losses from fire and related hazards consistent with the best class of protected property in private industry. Therefore, WCH has implemented the following fire protection measures:

- Contractually mandated fire protection criteria identified in DOE orders and federal, state, and local requirements

- A comprehensive fire and related hazards protection program for facilities sufficient to minimize the potential for the following:

  - The occurrence of a fire or related event

  - A fire that causes an onsite or offsite release of hazardous or radiological material that will threaten the health and safety of employees, the public, or the environment

  - Vital DOE programs suffering interruptions as a result of fire and related hazards

  - Property losses from a fire and related events exceeding defined limits established by DOE.

The WCH overall fire protection policy is stated in SH-1-5.1, *Fire Protection* . Specific Fire Protection Program elements are also described in SH-1-10.6, *Fire Protection*. The WCH Fire Protection Program complies with the appropriate requirements of applicable CFR and National Fire Protection Association criteria as well as the additional requirements of DOE Headquarters and Richland Operations Office directives included in the River Corridor Closure Contract.

The fire protection implementing procedures are grouped into five major areas: (1) management and administration, (2) fire protection design, (3) fire protection systems, (4) fire prevention procedures, and (5) special hazard protection procedures.

5.2.10 Surveillance and Maintenance

Surveillance of the remediation activities at the 116-C-3 site will be performed. These surveillance activities may include the following:

- Planning, scheduling, and performing independent assessments of waste site activities to provide feedback to WCH management regarding compliance status and performance

- Verifying that the site's quality program meets the requirements of applicable regulations, DOE orders, and contractual requirements

- Administering the process for evaluating and reporting potential *Price-Anderson Amendments Act of 1988* noncompliances.

QA-1-1.7, "Surveillance," describes the process for scheduling, preparing, performing, documenting, responding to, and closing surveillances in accordance with the requirements of DOE O 414.1C, *Quality Assurance*, and 10 CFR 830, Subpart A, "Assessment."

Surveillances may be scheduled or unscheduled. When scheduled surveillances are performed, the appropriate individuals shall be notified in advance and a time shall be scheduled for the surveillance. When unscheduled surveillances are performed, the personnel and line management being surveilled shall be informed, as soon as possible, that surveillance will be performed.

5.2.11 Work Controls

Worksite analysis is used to provide the means to successfully identify and control safety issues in the workplace. This requires that a hazard analysis be performed for all new processes, material, or equipment before use. It also ensures that surveys, reviews, self-inspections, and/or regular examinations of processes and individual jobs are routinely conducted. Programmatic worksite controls include, but are not limited to, the following:

- Activities will be conducted in accordance with the subcontractor's material handling plan, SS HASP, and the WCH Radiological Control Program.
- The employee job task analysis supports the collection of potential hazard and exposure data necessary for a risk-based approach to employee medical monitoring.
- The RadCon group completes comprehensive surveys and trends the results of monitoring activities in areas where employees work.
- Industrial hygiene technicians perform personal and area exposure sampling and monitoring.
- An integrated team with representation from affected craft(s), Field Engineering, Safety, Industrial Hygiene, RadCon, and other professionals conduct a job hazard analysis of work in the planning stage. This is to ensure that all hazards are identified and that the appropriate work methods are used to further reduce the risk to workers and the environment. The job hazard analysis consists of job screening, data gathering, field walkdown, and group discussion of the hazards noted.
- Prior to release of the subcontract documents, a pre-job safety meeting is held with the project team. Craft and supervision discuss the activities and ensure that the proper controls are in place prior to commencing work. If problems are found with the subcontract documents, the package is revised.
- Each day, prior to start of work, a plan-of-the-day meeting is held to discuss those portions of the subcontract documents that will be performed during the upcoming shift. Craft and supervisors carefully plan work in accordance with the subcontract documents, SS HASP, RWP, and other control documents.
- Self-inspections shall be performed that are conducted at the project and functional level, including inspections of fire extinguishers and emergency spill kits, housekeeping inspections, fire inspections, respiratory protection inspections, facility surveillances, and operations inspections.

During remediation activities, site-specific work controls will include the following elements:

- A SS HASP will identify the hazards and necessary controls for protection of the workers.
- A trench box will be used to stabilize the excavation prior to personnel entry, if required.
- When piping or tank contents could potentially be exposed, workers will use the PPE specified by the SS HASP and RWP.

- Piping will be cut using extended-reach equipment such as remotely-operated shears mounted on an excavator. The extended-reach equipment will not be positioned over any tanks, only between the tanks.
- Only trained equipment operators will be used.
- The work environment will be maintained in a compliant state in accordance with the Occupational Safety and Health Administration.
- Containment will be provided, as appropriate
- Dust-suppression techniques (fixatives) will be applied, as necessary, to control fugitive dust.
- The size of the excavation will be limited to the minimum dimensions necessary to conduct remediation activities safely.
- Field safety oversight personnel (Industrial Hygiene and RadCon safety specialists) will be provided during excavation and remediation activities.

6.0 REFERENCES

10 CFR 830, "Nuclear Safety Management," *Code of Federal Regulations*, as amended.

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.

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APPENDIX A

116-C-3 REMEDIATION HAZARD IDENTIFICATION TABLE

APPENDIX A

116-C-3 REMEDIATION HAZARD IDENTIFICATION TABLE

A.1 116-C-3 CHEMICAL TANKS HAZARDS IDENTIFICATION

The hazard identification table has six columns; the column headings and contents are described as follows:

Column 1 – Hazard Type. This column identifies the following types of hazards investigated: radiological (including radioactive material and direct radiation), fissile material, hazardous chemicals, biohazards, asphyxiates, flammable/combustible material, reactive material, explosive material, electrical energy, thermal energy, kinetic energy, noise, seismic, high wind, and water intrusion.

Column 2 – Location. This column describes the location of the hazard.

Column 3 – Form. This column specifies the form of the hazard type. This column is not intended to provide a detailed identification of the chemical (e.g., oxide) or physical form of the hazard type (e.g., crystalline). Such detail is not considered at the hazard identification stage of a safety analysis.

Column 4 – Quantity. This column quantifies the hazard. Measured values are presented when relevant and available. A "U" in this column indicates that the sampling result for the contaminant of interest was not statistically above background.

Column 5 – Remarks. This column presents information that provides a better understanding of the hazard type, location, form, and quantity.

Column 6 – References. This column lists the information sources used to identify the location, form, and quantity of a given hazard type.

Table A-1. 116-C-3 Chemical Tanks Remediation Hazard Identification Table. (9 Pages)

Hazard Type	Location	Form	Quantity		Remarks	References
Radioactive material	North tank: 102,200-L (27,000-gal) subgrade tank with associated piping and vents located adjacent to C Reactor.	Liquid at bottom of tank. There is no sludge in the north tank.	No radiological data for the north tank exist; however, field radiological measurements collected during confirmatory sampling indicated no significant detectable radiological activity. As a measure of conservatism, the concentrations for liquid in the south tank have been applied to the north tank.		The north tank currently holds approximately 2.5 cm (1 in.) of liquid at the tanks bottom, which equates to approximately 1,276 L (337 gal) of liquid.	*Partial Remaining Sites Verification Package for the 116-C-3, Chemical Waste Tanks*, attachment to CCN 112493 (BHI 2005)
	South tank: 102,200-L (27,000-gal) subgrade tank with associated piping and vents located adjacent to C Reactor.	Liquid.	**Isotope**	**Quantity (Ci)**	The south tank is currently filled to one-third of capacity, which equates to approximately 34,070 L (9,000 gal) of a liquid/sludge mixture. Sample No. J024M8, collected 11/30/04.	*Partial Remaining Sites Verification Package for the 116-C-3, Chemical Waste Tanks*, Table B-1, attachment to CCN 112493 (BHI 2005)
			H-3	2.0E-03		
			C-14	7.1E-04		
			Co-60	3.3E-04		
			Sr-90	8.7E-02		
			Cs-137	1.1E+00		
			U-233/234	1.2E-04		
			U-238	1.3E-04		
		Sludge/solids.	**Isotope**	**Quantity (Ci)**	For the south tank, an estimated 378.5 L (100 gal) of sludge is present. Sample No. J024M8-A, collected 11/30/04.	*Partial Remaining Sites Verification Package for the 116-C-3, Chemical Waste Tanks*, Table B-1, attachment to CCN 112493 (BHI 2005)
			H-3	1.4E-03		
			C-14	7.8E-04		
			Co-60	2.1E-02		
			Ni-63	6.9E+00		
			Sr-90	7.7E+00		
			Y-90	7.7E+00		
			Cs-137	1.0E+00		
			Eu-152	2.8E-03		
			Eu-154	3.3E-03		
			U-233/234	4.6E-03		

Table A-1. 116-C-3 Chemical Tanks Remediation Hazard Identification Table. (9 Pages)

Hazard Type	Location	Form	Quantity		Remarks	References
Radioactive material (continued)			U-238	4.7E-03		
			Pu-239/240	1.8E+00		
			Pu-241	1.8E+00		
			Am-241	4.1E-01		
			Pu-238	8.6E-03		
Fissionable materials	North and south tanks: 102,200-L (27,000-gal) each, subgrade tanks with associated piping and vents located adjacent to C Reactor.	Buried, partially buried, and exposed; inner and (potentially) outer surface, fixed and removable contamination on pipes and tanks, residual liquids in pipes and tanks, and as tank heel.	**Isotope**	**Quantity (Ci)**	The referenced criticality evaluation is for the sampling activities and is being revised to reflect the criticality impact resulting from the remediation activities as part of the documented safety analysis.	*Remediation of the 116-C-3 Underground Storage Tanks*, Criticality Evaluation No. 0100C-CE-N0005, Rev. 1 (revision in progress)
			U-235	7.62E-04		
			Pu-238	1.09E-01		
			Pu-239	2.66E+00		
			Pu-240	5.66E-01		
			Am-241	7.51E-01		
Hazardous chemicals	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Buried, partially buried, and exposed; inner and outer surfaces with fixed and removable contamination on pipes and tanks, residual liquids in pipes and tanks, and as tank heel. Contaminated soil and pipe/vessel contents.	The chemical inventory from both tanks is estimated to consist of the following: Arsenic Barium Cadmium Chromium Lead Silver Sodium	 0.004 kg 130 kg 27 kg 735 kg 183 kg 0.001 kg 19,342 kg	Of these chemicals, the only item with a reportable quantity listed in 40 CFR 302.4 is sodium with a reportable quantity of 454 kg (1,000 lb). There are no 29 CFR 1910 highly hazardous chemicals, nor are there any 40 CFR 68.130 regulated toxic substances documented for this site. Addition of chemicals could cause release of toxic fumes and/or heat.	*Determination of Material at Risk (MAR) for 116-C-3*, 0100C-CA-N0011 (BHI 2005a)

Table A-1. 116-C-3 Chemical Tanks Remediation Hazard Identification Table. (9 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Carcinogens	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Contaminants in soil and pipe/vessel contents.	There are no carcinogens documented for this site.	These hazards are routinely encountered in industry.	*Determination of Material at Risk (MAR) for 116-C-3*, 100C-CA-N0011 (BHI 2005a)
Biohazards	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Insect/rodent bites and excrement. Venomous insects and animals.	Undefined quantities.	These hazards are routinely encountered in the construction industry.	--
Asphyxiates	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Heavier-than-air gasses.	Estimated quantities: Acetylene: 45 kg (100 lb) Propane: 400 L (106 gal)	The potential for the collection of asphyxiate gasses to dangerous concentrations is credible because of the subgrade nature of the facility.	--

Table A-1. 116-C-3 Chemical Tanks Remediation Hazard Identification Table. (9 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Flammable materials	Two 102.200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Range fire or onsite fire.	Minimal quantities of vegetation and combustible materials within site boundary.	A range fire would not cause a significant release of hazardous substances due to the lack of combustibles, especially vegetation, within the remediation site.	--
	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to the C Reactor.	Miscellaneous combustibles.	Undefined quantities of combustibles on vehicles.	Miscellaneous combustible materials include pieces of plastic, wood, cloth, and other types generated during remediation.	--
		Fuels and oils.	materials will be kept to the minimum needed to support the project. Estimated quantities are as follows: Gasoline 190 L (50 gal) Diesel 7,600 L (2,008 gal) Lubricating oil 570 L (151 gal) Paints, cleaners, solvents or adhesives: 380 L (1 00 gal) Acetylene: 2.8E+04 L (7,397 gal) Antifreeze: 450 L (119 gal) Brake fluid: 19 L (5 gal) Hydraulic/ transmission fluid: 760 L (201 gal) Propane: 400 L (106 gal)	Fuels and oils are found in vehicles brought onsite as part of the remediation activities. These materials will not be stored close to the site.	Estimated quantities based on ERC Chemical Inventory Database for 100-B/C
Corrosives	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Liquids in tanks and pipes.	Unknown quantities of 50% NaOH and 10% HNO_3 were sent to these tanks (see hazardous chemicals).	The high pH measured in the 116-C-3 waste (13.2) would indicate that the HNO_3 has been neutralized.	--

Table A-1. 116-C-3 Chemical Tanks Remediation Hazard Identification Table. (9 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Explosive materials	116-C-3 remediation site.	Gasoline and diesel fuel. Propane and other pressurized gas bottles. Radiolytic decomposition of water creating hydrogen gas.	Undefined quantities. Quantities of gasoline and diesel fuel will be kept to the minimum needed to support the project.	Gasoline and diesel fuel is present in various vehicles onsite (e.g., heavy machinery used for excavation or transport). For propane and other pressurized gas bottles, see the kinetic and potential energy hazard type.	--
Reactive hazards	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to the C Reactor.	Solids and liquids.	Reactive hazards are not expected to be currently present at the waste site; however, reactive hazards (e.g., grout, additives) brought on site for treatment of tank contents may be reactive.	An explosion could cause some amount of contaminated soils to be suspended in air and be readily breathable to a downwind receptor or initiate a fire (see the hazardous chemicals hazard type).	
Electrical energy	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to the C Reactor.	Supply lines outside of the excavation fence for office trailers and analytical needs.	No dedicated lines will be brought to the site. If electrical service is required, a portable generator will be brought to the site. There are 230-Kv lines within 100 m of the site.	See remarks for flammability and kinetic/potential energy hazard types.	--
		Lightning	Undefined quantities.	Lightning could initiate a fire. These hazards are routinely encountered in industry.	--
Thermal energy	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Extreme temperatures.	N/A	Temperature extremes range from -29 to 46°C (-20 to 115°F). These hazards are routinely encountered in industry.	--

Table A-1. 116-C-3 Chemical Tanks Remediation Hazard Identification Table. (9 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Kinetic and potential energy	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Pressurized gas bottles (e.g., oxy-acetylene).	Such materials will be kept to the minimum needed to support the project.	A pressurized missile could strike a patch of contaminated soil, which would result in a release of material.	--
		Falling loads/equipment used during remediation activities.	Undefined quantities	A falling load could cause a puff-type release of contaminated soils. Heavy machinery may collide with the tanks causing contaminated particles to be released into the air.	--
		Aircraft collision.	Undefined quantities.	The probability of this type of event is extremely low, especially given the small footprint of this site. An aircraft collision would cause contaminated soils to be suspended in air. There would also be a potential for a fire to result from the crash (see flammability hazard type for fire) to become airborne.	--
	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Heavy equipment/ machinery/vehicle impacting the tanks, piping, or contaminated soil.	Accumulation of hydrogen gas is not expected because the tanks and pipelines have been vented during the last year.	Sparks generated during rupturing of tanks/pipes may result in combustion of hydrogen/oxygen mixtures, causing venting of the tanks. This hazard requires a sufficient concentration of hydrogen, which is unavailable because the tanks have been vented to the atmosphere.	--
	116-C-3 remediation site.	A filled waste drum being dropped a vertical distance.	Undefined quantities.	For those drums containing contaminated waste, it is assumed that a drop would be insufficient to cause a total ejection of the drum contents. A drum would have to be open for dispersion of contents to occur. Such a rupture is not anticipated to result in a large airborne release due to the relatively small fraction of inventory represented by the volume of a single drum.	--

Table A-1. 116-C-3 Chemical Tanks Remediation Hazard Identification Table. (9 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Noise	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Machinery/equipment.	Undefined quantities of machinery present.	These hazards are routinely encountered in industry.	--
Water intrusion – natural phenomenon	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Flooding.	--	Spread of contamination could occur; however, the arid-to-semiarid climate and the high permeability of the soil suggest that little, if any, surface water will accumulate within the excavation. Most precipitation is lost through evapotranspiration. Consequently, little water remains to generate surface runoff.	--
		Rainwater/snow and ice.	--	The arid-to-semiarid climate suggests that little, if any, water accumulates within the excavation. Most precipitation is lost through evapotranspiration. In addition, the transmissive nature of the Hanford Site surface soils allows rapid infiltration of precipitation. Consequently, little water remains to generate surface runoff.	--
		Liquids used for dust or fire suppression or addition of liquids for treatment.	Undefined quantities.	The transmissive nature of the Hanford Site surface soils allows rapid infiltration of water.	--

Table A-1. 116-C-3 Chemical Tanks Remediation Hazard Identification Table. (9 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Seismic – natural phenomenon	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Contaminated soil and pipe/vessel contents.	The volume of contaminated soil, pipe scale, and vessel contents at risk for the excavation site.	Falling debris, equipment, and heavy machinery could impact contaminated soil/tanks and result in a puff-like release. The severity of a seismic event at the Hanford Site is not anticipated to result in significant impacts to subgrade waste site structures. The effects of a seismic event on the Hanford Site or other facilities and projects would be much more significant than those consequences that would occur at the 116-C-3 site (see the kinetic energy hazard type).	--
High wind – natural phenomenon	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Probable maximum wind.	Peak gusts have been recorded at 80 mph at 15.2 m (50 ft) above grade. Such extreme gusts have not exceeded a full day in duration.	Contaminated soils will be suspended in air and readily breathable to a downwind receptor. Could cause debris to be thrown (a missile) causing a kinetic energy hazard.	--
Tornado – natural phenomenon	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Contaminated soil and pipe/vessel contents.	Undefined quantities.	A tornado could suspend contaminated soils in air, which would make them readily respirable to a downwind receptor. Could cause debris to be thrown (a missile) causing a kinetic energy hazard.	--

Table A-1. 116-C-3 Chemical Tanks Remediation Hazard Identification Table. (9 Pages)

Hazard Type	Location	Form	Quantity	Remarks	References
Exposure – internal uptake	Two 102,200-L (27,000-gal) subgrade tanks with associated piping and vents located adjacent to C Reactor.	Contaminated soil and pipe/vessel contents.	See quantities for the radiological hazard type.	During remediation activities, contaminated soil or tank/pipe contents will be handled in various ways. Soils or tank/pipe contents may be spilled causing these materials to adhere to soil particles, which could be suspended in air. Movement of workers and vehicles across contaminated soil may also result in an airborne release leading to an internal uptake.	*Initial Hazard Categorization for the 116-C-3 Underground Storage Tanks*, 0100C-CA-N0008 (BHI 2004)

A.2 REFERENCES

29 CFR 1910, "Occupational Safety and Health Standards," *Code of Federal Regulations*, as amended.

40 CFR 68, "Chemical Accident Prevention Provisions," *Code of Federal Regulations*, as amended.

40 CFR 302, "Designation, Reportable Quantities, and Notification," *Code of Federal Regulations*, as amended.

BHI, 2004, *Initial Hazard Categorization for the 116-C-3 Underground Storage Tanks*, Calculation No. 0100C-CA-N0008, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 2005, *Partial Remaining Sites Verification Package for the 116-C-3, Chemical Waste Tanks*, attachment to CCN 112493, dated March 28, Bechtel Hanford, Inc., Richland, Washington.

APPENDIX B

116-C-3 CHEMICAL TANKS REMEDIATION HAZARD EVALUATION TABLE

APPENDIX B

116-C-3 CHEMICAL TANKS REMEDIATION HAZARD EVALUATION TABLE

B.1 GENERAL METHODOLOGY

All events that could result in a potential release of hazardous substances were evaluated using the following approach:

- Events were grouped into three categories: operational/internal events, natural phenomena events, and external/man-made events.
- Events that were not applicable (flooding due to probable maximum flood, failure of engineered ventilation or filtration systems) were noted as not applicable (N/A).
- Frequency, consequence, and risk rankings were not assigned for events (e.g., loss of power to equipment) that could not result in a release of hazardous substances. These events are noted as not evaluated (N/E) in the corresponding columns.
- Consequence and risk rankings were not assigned to events with an assigned unmitigated frequency of D, beyond extremely unlikely. N/E is noted in the corresponding columns.

B.2 FREQUENCY RANKS

Frequency ranks were assigned using the following guidelines and the event frequency rank chart shown in Table B-1.

- The frequency of the initiating event is the unmitigated frequency.
- Initiating events that involved human error were assigned an unmitigated frequency rank of A.
- Initiating events that involved failure of an active component were assigned an unmitigated frequency rank of A.
- Initiating events that involved failure of a passive component were assigned an unmitigated frequency rank of B.
- Fire initiators involving use of an ignition source (e.g., vehicle exhaust systems, compressed gas torches) were assigned a frequency rank of A.
- Frequency assigned to natural phenomenon events assigned consistent with frequency of applicable evaluation basis event.
- Events that would not result in a potential release of hazardous substances (e.g., loss of power caused by vehicle accident) were not evaluated for frequency.

Table B-1. Event Frequency Ranks.

Term	Rank	Description	Frequency Range (yr-1)
Anticipated	A	May occur several times in the life of the facility	>1E-02
Unlikely	B	Not anticipated to occur during the life of the facility	1E-04 to 1E-02
Extremely unlikely	C	Probably will not occur in the life of the facility	1E-06 to 1E-04
Beyond extremely unlikely	D	All other events	<1E-06

B.3 CONSEQUENCE RANKS

Consequence ranks for the public, co-located worker, and facility worker were assigned based on anticipated unmitigated dose using the charts shown in Tables B-2 through B-4. For events that were assigned a frequency of beyond extremely unlikely (event frequency D), the consequences were not evaluated.

Table B-2. Public Consequence Ranks.

Term	Rank	Dose Range	Concentration Range
High	1	>25 rem TEDE	>ERPG-2/TEEL-2
Moderate	2	1 to 25 TEDE	ERPG-1/TEEL-1 to ERPG-2/TEEL-2
Low	3	0.1 to 1 rem TEDE	<ERPG-1/TEEL-1 to ERPG-2/TEEL-2
Negligible	4	<0.1 rem TEDE	<ERPG-1/TEEL-1

ERPG = emergency response planning guideline
TEDE = total effective dose equivalent
TEEL = temporary emergency exposure limit

Table B-3. Co-Located Worker Consequence Ranks.

Term	Rank	Dose Range	Concentration Range
High	1	>100 rem TEDE	>ERPG-3/TEEL-3
Moderate	2	25 to 100 rem TEDE	ERPG-2/TEEL-2 to ERPG-3/TEEL-3
Low	3	1 to 25 rem TEDE	<ERPG-1/TEEL-1 to ERPG-2/TEEL-2
Negligible	4	<1 rem TEDE	<ERPG-1/TEEL-1

ERPG = emergency response planning guideline
TEDE = total effective dose equivalent
TEEL = temporary emergency exposure limit

Table B-4. Facility Worker Consequence Ranks.

Term	Rank	Exposure to Radioactivity or Other Hazardous Materials Characterization
High	1	Severe exposure resulting in prompt fatality
Moderate	2	Significant exposure (>100 rem TEDE or severe injury)
Low	3	Moderate exposure (10 to 100 rem TEDE, reversible health effects)
Negligible	4	<Low

TEDE = total effective dose equivalent

B.4 RISK RANKS

Unmitigated frequency and consequence ranks were used to determine unmitigated risk ranks in accordance with B-5.

Table B-5. Risk Ranks.

Consequence Rank	Frequency Rank			
	A	B	C	D
1	I	I	II	III
2	I	II	III	IV
3	III	III	IV	IV
4	IV	IV	IV	IV

Table B-6. Hazard Evaluation Table. (11 Pages)

Item	Summary				Unmitigated Ranking			Prevention and Mitigation	
	Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	Systems, Structures, and Components	Administrative
1.	Seismic event	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure. Kinetic and potential energy hazards.	It is not anticipated that a seismic event impacting the Hanford Site will have sufficient energy to result in the shifting of soil slopes. The soil slopes at the 116-C-3 site will be sufficiently moist to prevent cascading of soil and undermining of slope bases. Any minimal amount of contaminated dust that would be made airborne due to a seismic event or from after effects (e.g., falling equipment, overturned vehicles) would be bounded by high-wind hazards.	Public: C Facility worker: C Coloc. worker: C	Public: 3 Facility worker: 3 Coloc. worker: 3	Public: IV Facility worker: IV Coloc. worker: IV	--	Access control, PPE for personnel, radiological controls, spill response procedures, ERC Emergency Management Program (P&M)
2.	High wind/ tornado	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure. Kinetic and potential energy hazards.	High winds or a tornado would disturb soil surfaces and suspend contaminated particles into the air. Airborne contamination could readily spread from the remediation area to onsite receptors. The probability of a tornado impacting the 116-C-3 site is assessed as being beyond extremely unlikely. Therefore, further consideration is not required.	Public: A Facility worker: A Coloc. worker: A	Public: 3 Facility worker: 3 Coloc. worker: 3	Public: III Facility worker: III Coloc. worker: IIIII	--	Access control, dust-suppression procedures, PPE for personnel, radiological controls, ERC Emergency Management Program (P&M)

Table B-6. Hazard Evaluation Table. (11 Pages)

Item	Summary				Unmitigated Ranking			Prevention and Mitigation	
	Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	Systems, Structures, and Components	Administrative
3.	Snow/ash loading	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure. Kinetic and potential energy hazards.	Ash and/or snow would bury contaminated soil, tanks, and piping. There are no structures whose failure would result in significant releases of contaminated soil. Impacts resulting from equipment collapsing under the weight of snow and ash would be minimal, as the significant layers of snow and ash would entrap the majority of any inventory that would be expected to be released from soil or from a breached tank or pipe. Because there is no evidence of any lava, mud, or ashflows reaching the Pasco Basin within the recent past, and the nearest volcano is more than 97 km (60 mi) from the Hanford Site, volcanic activity is considered unlikely to impact the Hanford Site.	Public: D Facility worker: C Coloc. worker: C	Public: 3 Facility worker: 3 Coloc. worker: 3	Public: IV Facility worker: IV Coloc. worker: IV	--	ERC Emergency Management Program (M)

Table B-6. Hazard Evaluation Table. (11 Pages)

Item	Summary				Unmitigated Ranking			Prevention and Mitigation	
	Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	Systems, Structures, and Components	Administrative
4.	Potential impacts from other facilities and offsite activities	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure. Kinetic and potential energy hazards.	Potential energy sources and associated accidents beyond 100 m (328 ft) from the 116-C-3 site are considered to have no impact. Review of hazard assessments and safety analyses for nearby facilities in the 100 Area determined that there are no accident scenarios that could occur at these facilities that would result in a release from the 116-C-3 site. Evaluation of the bounding accidents involving the release of contaminated material at the 116-C-3 site determined that subsequent evacuation of the 116-C-3 site would not result in unacceptable doses, as there are no critical monitored processes that require the presence of personnel.	Public: C Facility worker: C Coloc. worker: C	Public: 3 Facility worker: 3 Coloc. worker: 3	Public: IV Facility worker: IV Coloc. worker: IV	--	ERC Emergency Management Program (M)
5.	Aircraft impact	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure. Kinetic and potential energy hazards.	Based on DOE-STD-3014, an aircraft crash at the 116-C-3 waste site is considered beyond extremely unlikely. Therefore, further consideration is not required.	Public: D Facility worker: D Coloc. Worker: D	Public: NE Facility worker: NE Coloc. Worker: NE	Public: NE Facility worker: NE Coloc. Worker: NE	--	ERC Emergency Management Program

Table B-6. Hazard Evaluation Table. (11 Pages)

Item	Summary				Unmitigated Ranking			Prevention and Mitigation	
	Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	Systems, Structures, and Components	Administrative
6.	Vehicle impact	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure. Kinetic and potential energy hazards.	Vehicles falling into the excavation site could result in airborne suspension of contaminated soil. Rupturing of fuel tanks could result in a fire (see item 8 for possible effects of a range fire, and item 9 for possible effects of an onsite fire).	Public: A Facility worker: A Coloc. worker: A	Public: 3 Facility worker: 3 Coloc. worker: 3	Public: III Facility worker: III Coloc. worker: III	--	Dust-suppression procedures, access control, PPE for personnel, radiological controls, fire protection procedures.
7.	Range fire	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure. Kinetic and potential energy hazards.	Range fires or small fires started at the waste site may ignite miscellaneous combustible materials, including pieces of plastic, wood, vegetation, cloth, and other combustibles generated during remediation. Also, fuels and oils found in vehicles would be available to propagate a fire. The fire could result in a release of hazardous substances via entrainment or from the combustion of contaminated flammable materials. A fire may also result in an explosion (see item 11 for causes of an explosion). A fire may result in an internal missile (see item 12 for causes of internal missiles at a waste site). See item 9 for discussion of fire impact within the 116-C-3 site.	Public: A Facility worker: A Coloc. worker: A	Public: 3 Facility worker: 3 Coloc. worker: 3	Public: III Facility worker: III Coloc. worker: III	--	Good housekeeping practices, access control, fire protection procedures, restriction on open-flame use, storage requirements, Emergency Management Program (for range fires) Dust suppression (e.g., soil cement, water) Passive physical barriers defining the sampling and remediation area restrict the spread of fire from impacting staged drums

Table B-6. Hazard Evaluation Table. (11 Pages)

Item	Summary				Unmitigated Ranking			Prevention and Mitigation	
	Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	Systems, Structures, and Components	Administrative
8.	Onsite fire	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure. Kinetic and potential energy hazards.	A fire occurring within the waste site may entrain exposed contaminated soil at the site.	Public: B Facility worker: B Coloc. worker: B	Public: 3 Facility worker: 3 Coloc. worker: 3	Public: III Facility worker: III Coloc. worker: III	--	Good housekeeping practices, access control, fire protection procedures, restriction on open-flame use, storage requirements, Emergency Management Program
9.	Lightning	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure. Kinetic and potential energy hazards.	The probability of a lightning strike directly to a waste site is significantly below the probability of 1×10^{-6}/yr. However, lightning can initiate a range fire, which can impact waste sites. See item 8 for a discussion of the impacts of a range fire.	Public: D Facility worker: D Coloc. worker: D	Public: NE Facility worker: NE Coloc. worker: NE	Public: NE Facility worker: NE Coloc. worker: NE	--	Good housekeeping practices, access control, fire protection procedures, storage requirements, Emergency Management Program (for range fires)

Table B-6. Hazard Evaluation Table. (11 Pages)

Item	Summary				Unmitigated Ranking			Prevention and Mitigation	
	Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	Systems, Structures, and Components	Administrative
10.	Explosion	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure. Kinetic and potential energy hazards.	An explosion could occur at the site causing contaminated soil to be released into the air. The explosion may also initiate a range fire (see item 7 for the consequences of a range fire). Possible causes: deflagration of flammable gas/air mixtures due to equipment failure and/or human error; bottles of pressurized flammable gases at the remediation site; accumulation of hydrogen/oxygen mixture within the tanks, followed by deflagration.	Public: C Facility worker: C Coloc. worker: C	Public: 3 Facility worker: 3 Coloc. worker: 3	Public: IV Facility worker: IV Coloc. worker: IV	--	Good housekeeping practices, access control, fire protection procedures, restriction on open-flame use, storage requirements, Emergency Management Program (for range fires) Venting of tanks' pipelines
11.	Internal missiles	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure. Kinetic and potential energy hazards.	An internal missile may strike a patch of contaminated soil resulting in a puff-like release. Possible causes: punctured container of pressurized gas, and a fire melting the release valve of a bottle of pressurized gas.	Public: C Facility worker: C Coloc. worker: C	Public: 3 Facility worker: 3 Coloc. worker: 3	Public: IV Facility worker: IV Coloc. worker: IV	--	Good housekeeping practices, access control, fire protection procedures, restriction on open-flame use, pressurized container storage requirements, Emergency Management Program Dust suppression

Table B-6. Hazard Evaluation Table. (11 Pages)

Item	Summary				Unmitigated Ranking			Prevention and Mitigation	
	Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	Systems, Structures, and Components	Administrative
12.	Heavy load drop equipment impact	Soils, waste-filled drums, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, reactive materials exposure. Kinetic and potential energy hazards.	A heavy load drop may strike a patch of contaminated soil, tanks, or pipelines, resulting in a puff-like release of airborne inventory. Possible causes: overturned vehicles, falling equipment, dropped loads, etc.	Public: A Facility worker: A Coloc. worker: A	Public: Negligible4 Facility worker: 3 Coloc. worker: 3	Public: IV Facility worker: III Coloc. worker: III	--	Dust-suppression procedures, access control, PPE for personnel, radiological controls, hoisting and rigging procedures
13.	Nuclear criticality	Soils, exposed tanks and piping within the 116-C-3 site	Fissionable materials	A criticality screening was performed for the 116-C-3 site inventory (0100C-CE-N0005). The screening determined that over-moderation precludes criticality. Further, the fissionable materials concentrations present are too low to create credible criticality hazard.	Public: D Facility worker: D Coloc. worker: D	Public: NE Facility worker: NE Coloc. worker: NE	Public: NE Facility worker: NE Coloc. worker: NE	--	
14.	Flooding caused by fire/dust suppression	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure.	Fire/dust-suppression liquids would accumulate in a waste site due to excessive liquids being used to suppress dust or fight a fire. Excess liquids could result in the spread of contamination off the remediation site.	Public: C Facility worker: C Coloc. worker: C	Public: 3 Facility worker: 3 Coloc. worker: 3	Public: IV Facility worker: IV Coloc. worker: IV	--	Access control, fire protection procedures, PPE for personnel, radiological controls, personnel dosimetry

Table B-6. Hazard Evaluation Table. (11 Pages)

	Summary				Unmitigated Ranking			Prevention and Mitigation	
Item	Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	Systems, Structures, and Components	Administrative
15.	Probable maximum flood	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure.	A probable maximum flood would not impact the 116-C-3 waste site.	Public: C Facility worker: C Coloc. worker: C	Public: 3 Facility worker: 3 Coloc. worker: 3	Public: IV Facility worker: IV Coloc. worker: IV	--	ERC Emergency Management Program
16.	Catastrophic flood	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure.	Entire facility inundated due to the catastrophic flood anticipated following the 25% or 50% breach of the Grand Coulee Dam.	Public: D Facility worker: D Coloc. worker: D	Public: NE Facility worker: NE Coloc. worker: NE	Public: NE Facility worker: NE Coloc. worker: NE	--	ERC Emergency Management Program

Table B-6. Hazard Evaluation Table. (11 Pages)

Item	Summary				Unmitigated Ranking			Prevention and Mitigation	
	Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	Systems, Structures, and Components	Administrative
17.	Container spill	Soils within containers within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure. Kinetic and potential energy hazards.	Container of soil is spilled while preparing for shipment or analysis.	Public: A Facility worker: A Coloc. worker: A	Public: Negligible4 Facility worker: 3 Coloc. worker: 3	Public: IVIV Facility worker: IIIII Coloc. worker: III	--	Access control, spill response procedures, PPE for personnel, radiological controls, personnel dosimetry For the characterization activities covered by this safety analysis, sample containers will be limited to a maximum of 1.5 kg, unless the area being sampled is a high-radiation area, in which case the sample mass will be limited to 20 g
18.	Soil spill (Dumping)dumping)	Soils within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure.	Equipment used to remove contaminated soil results in the unplanned dumping (hydraulic hose break) of soil. It is assumed that the contents are in a powder form, are suspended in air from the energy of the fall, and that the wind will carry the airborne material into the environment.	Public: A Facility worker: A Coloc. worker: A	Public: 3 Facility worker: 3 Coloc. worker: 3	Public: III Facility worker: III Coloc. worker: III	--	Dust-suppression procedures, access control, PPE for personnel, spill response procedures, radiological controls, personnel dosimetry

Table B-6. Hazard Evaluation Table. (11 Pages)

Item	Summary				Unmitigated Ranking			Prevention and Mitigation	
	Initiator	Location	Affected Hazard	Event Description	Frequency	Consequence	Risk	Systems, Structures, and Components	Administrative
19.	Spread of contaminatio n	Soils, exposed tanks, and piping within the 116-C-3 site	Radiological, fissionable materials, hazardous chemicals, carcinogens, corrosives, and reactive materials exposure.	Surface contamination and/or contaminated material are spread from designated areas via personnel vehicle contamination.	***Frequency Rank:*** Public: A Facility worker: A Coloc. worker: A	***Consequence Rank:*** Public: Negligible Facility worker: Negligible Coloc. worker: Negligible	***Risk Rank:*** Public: IV Facility worker: IV Coloc. worker: IV	--	Dust suppression, access control, radiological controls, PPE for personnel, personnel dosimetry

ERC = Environmental Restoration Contractor
EDPI = Engineering Department Project Instruction
PFP = Plutonium Finishing Plant
PPE = personal protective equipment

B.5 REFERENCES

BHI, 2004, *Remediation of the 116-C-3 Underground Storage Tanks*, 0100C-CE-N005, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

DOE, 1996, *Accident Analysis for Aircraft Crash into Hazardous Facilities*, DOE-STD-3014-96, U.S. Department of Energy, Washington, D.C.

APPENDIX C

FINAL HAZARD CATEGORIZATION CALCULATION

APPENDIX C

FINAL HAZARD CATEGORIZATION CALCULATION

CALCULATION COVER SHEET

Project Title 116-C-3 Tank Remediation **Job No.** **14655**

Area 100-B/C Area

Discipline Nuclear/Safety Engineering ***Calc. No.** 0100C-CA-N0012

Subject 116-C-3 Remediation Final Hazard Categorization Calculation (Revised TQs)

Computer Program Excel **Program No.** 2003

The attached calculations have been generated for a specific purpose and task. Use of these calculations by persons who do not have access to all pertinent facts may lead to incorrect conclusions and/or results. Before applying these calculations to your work, the underlying basis, rationale, and other pertinent information relevant to these calculations must be thoroughly reviewed with appropriate Washington Closure Hanford LLC (WCH) officials or other authorized personnel. WCH is not responsible for the use of a calculation not under its direct control.

Committed Calculation ☒ **Preliminary** ☐ **Superseded** ☐ **Voided** ☐

Rev.	Sheet Numbers	Originator	Checker	Reviewer	Approval	Date
0	Cover – 1 Calc. – 11 Total - 12	T.M. Blakley	M. F. Maxson	R.R. Lehrschall	J. S. Decker	07-27-2005
1	Cover – 1 Calc. – 12 Total – 13	M.W. Ellis	T. J. Rodovsky	J. D. Ludowise	J. S. Decker	4/6/07

SUMMARY OF REVISION

1	This calculation was revised to include an additional treatment option for the liquid waste contained within the 116-C-3 tanks. The process allows a sluicing operation to remove the liquid waste from the tanks using a low pressure pump and piping/hose assembly operating at less than 50 psig and treated/solidified outside the tanks.

WCH-DE-019 (04/14/2006) *Obtain Calc. No. from R&DC and Form from Intranet

Bechtel Hanford, Inc. **CALCULATION SHEET**

Originator:	**T. M. Blakley** TMB	**Date:** **7/25/2005**	**Calc. No.:** **0100C-CA-N0012**	**Rev. No.:**	**0**
Project:	**116-C-3 Remediation**	**Job No.:** **22192**	**Checked:** **M.F. Maxson** MFM	**Date:**	7/28/05
Subject:	**116-C-3 Final Hazard Categorization Calculation (Revised TQs)**			**Sheet No.:**	**1 of 12**

1.0 Table of Contents:

2.0 Summary of Results:

The 1027 Category 3 sum-of-the-ratios for the 116-C-3 Underground Storage Tank characterization activities is 1.7E-01, which is below 1; therefore, the final hazard categorization for this activity is below Category 3.

0100C-CA-N0012_Rev_0_116-C-3_FHC Revised TQ Values/Calc (1) (TOC, Results)

Bechtel Hanford, Inc. **CALCULATION SHEET**

Originator:	M.W. Ellis	Date: 3/22/2007	Calc. No.: 0100C-CA-N0012	Rev. No.:	1
Project:	116-C-3 Remediation	Job No.: 14655	Checked: T.J. Rodovsky TJR	Date:	3/22/07
Subject:	116-C-3 Final Hazard Categorization Calculation (Revised TQs)			Sheet No.:	2 of 12

3.0 Purpose

The purpose of this calculation is to determine the Final Hazard Categorization (FHC) for the 116-C-3 Underground Chemical Storage Tanks remediation activities based on the hazard analysis of the proposed activities.

4.0 Assumptions

The 116-C-3 waste site consists of two (2) 102,200-liter (27,000-gallon) underground tanks. The tanks received waste solutions from the 105-C Metal Examination Facility (MEF) fuel slug dejacketer (Bokish and Reynolds 1956).

The hazards evaluated in this calculation are identified in Appendix A of the *Auditable Safety Analysis and Final Hazard Categorization for the 116-C-3 Chemical Tank Remediation Activities* (BHI 2005b). Release of radiological, chemical, and fissionable materials could potentially occur due to several initiators, including fire (onsite or range), explosion (deflagration), entrainment due to high winds, dumping or spilling of sample content, spray release of liquid waste while pumping the material out of the tank for soldification, impact from excavation equipment or vehicles, fire due to lightning, pressurized gas bottles striking samples or piping, or dumping/spilling due to seismic activity. Accident scenarios for entrainment, fire event, explosion, dumping/spilling, and vehicle impact are evaluated in this calculation. Assumptions for each of these events are included in the following table:

Waste Type	High Wind Event	Fire Event (due to any Initiator)	Explosion (deflagration of flammable gas/air mixture)	Dump/ Spill/Spray Event	Vehicle/ Equipment Impact
Soil/Pulverized Grout	High winds could impact and resuspend contaminated soil/pulverized grout during remediation activities.	Fire event is judged to have negligible impact on contaminated soil/grout matrix.	Pressure rise resulting from a deflagration of flammable gas/air mixture during remediation activities causing a resuspension of contaminated soil.	Dumping/dropping of contaminated soil/grout matrix during remediation activities causing a release.	Excavation equipment or vehicles could resuspend contaminated soil/grout and cause an airborne release. While discussed in this calculation, release from aircraft impact is considered beyond extremely unlikely.
Tank sludge/liquid	High wind event could resuspend tank sludge/liquid not contained in tanks. Majority of this waste will be protected from high winds due to location within below-grade tanks prior to grouting operations.	Fire has the potential to heat the liquid/sludge causing a release of contaminated materials. Majority of waste will be protected from heat of fire due to location within below-grade tanks prior to or during grouting	Pressure rise resulting from a deflagration of flammable gas/air mixture during remediation activities could cause a release of liquid/sludge from the tanks prior to or during grouting operations.	Inadvertent spilling/spraying of liquid/sludge during grouting activities could occur causing a release of contaminated materials.	Excavation equipment could breach the tanks causing a release of contaminated material through initiation of a fire or dumping/spilling of tank contents.
Contaminated Combustible Solids	High wind event could resuspend freshly deposited surface contamination. Waste primarily in the form of personal protective equipment (PPE).	Stored PPE could be ignited during a fire event causing a release of contaminated materials.	Pressure rise resulting from a deflagration of flammable gas/air mixture during remediation activities could cause a release of surface contamination.	No significant release of contaminated materials from this type of solid (e.g., PPE) is expected due to high surface area to mass ratio.	Vehicle/equipment impact to packaged, contaminated PPE could result in a suspension of surface contamination.
Contaminated, Noncombustible Solids	High wind event could resuspend freshly deposited surface contamination. Waste primarily in the form of contaminated piping and tank structural materials.	Fire has the potential to heat these solids causing a release of contaminated materials. Majority of waste will be protected from heat of fire due to location below-grade.	Pressure rise resulting from a deflagration of flammable gas/air mixture during remediation activities could cause a release of surface contamination.	Damage/dropping of contaminated pipe or tank materials could result in a release of surface contamination.	Excavation equipment or vehicle could impact piping and/or tanks causing a release of surface contamination.

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Bechtel Hanford, Inc. **CALCULATION SHEET**

Originator:	**T. M. Blakley** TMB	**Date:**	**7/26/2005**	**Calc. No.:**	**0100C-CA-N0012**	**Rev. No.:**	**0**
Project:	**116-C-3 Remediation**	**Job No.:**	**22192**	**Checked:**	**M.F. Maxson** MFM	**Date:**	7/27/05
Subject:	**116-C-3 Final Hazard Categorization Calculation (Revised TQs)**					**Sheet No.:**	**3 of 12**

5.0 Methodology:

Step 1: Determine contaminated material inventories.

Contaminated material inventories (e.g., sludge, liquid, soil) are from 0100C-CA-N0011 (BHI 2005a). Only radionuclides are used in determining the FHC; therefore, analysis of chemical constituents is not included in this FHC calculation.

Step 2: Calculate the revised TQ values ($TQ_{REVISED}$)

The hazard Category 3 threshold quantities (TQ) in DOE-STD-1027-94 (DOE, 1997) are based on the release values (RV) calculated in (EPA, 1989.) Release values are determined for each of four exposure pathways: food ingestion, water ingestion, inhalation, and direct exposure. The TQ for a given isotope is 20 times the most restrictive RV. The TQ, presented in equation 1, can be expressed as:

$$TQ = 20 \times MIN \{ RV_{FOOD}, RV_{WATER}, RV_{INH}, RV_{DIR} \} \quad (1)$$

The EPA methodology uses the following assumptions:

1) The RV for the water ingestion pathway assumes that 100% of the material is released to drinking water (see EPA, 1989 Appendix B.1)
2) The RV for the inhalation pathway and the RV for the food ingestion pathway both are inversely proportional to a respirable airborne release fraction (see EPA, 1989 Appendix A.2 and Appendix C.1).
3) The RV for direct exposure for isotopes other than noble gases assumes a point source

The DOE Office of Nuclear and Facility Safety Policy Nuclear Safety Technical Position, NSTP 2002-2 (DOE, 2002), allows that the hazard Category 3 TQs for radionuclides for which the food pathway and the inhalation pathway are limiting may be revised if, based on the physical and chemical form and available dispersive energy sources for the facility and its hazardous materials, the credible release fractions (airborne release fractions) can be shown to be significantly different from the values used in the EPA Technical Background Document. All potential accident scenarios must be considered under unmitigated conditions. All pathways must be considered and the most limiting pathway must be used.

Based on the guidance in NSTP 2002-2, the revised Category 3 TQ for an isotope in a particular material form, presented in equation 2, can be expressed as:

$$TQ_{REVISED} = 20 \times MIN \{ f_1 \times RV_{FOOD}, f_2 \times RV_{WATER}, f_1 \times RV_{INH}, f_3 \times RV_{DIR} \} \quad (2)$$

Where	f_1	is the ratio of the respirable airborne release fraction used in the EPA analysis (from EPA, 1989 Exhibit A-1) to the largest respirable airborne release fraction from any potential accident
	RV_{FOOD}	is the release value for the food pathway from EPA, 1989 Appendix E
	f_2	is the ratio of the fraction of material released to drinking water in the EPA analysis (i.e., 1) to the largest fraction of material released to drinking water in any potential accident scenario
	RV_{WATER}	is the release value for the water pathway from EPA, 1989 Appendix E

0100C-CA-N0012_Rev_0_116-C-3_FHC Revised TQ Values/Calc (3) (Methodology Cont.)

Bechtel Hanford, Inc. **CALCULATION SHEET**

Originator:	T. M. Blakley TMB	Date:	7/25/2005	Calc. No.:	0100C-CA-N0012	Rev. No.:	0
Project:	116-C-3 Remediation	Job No.:	22192	Checked:	M.F. Maxson MFM	Date:	7/27/05
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5.0 Methodology (continued):

Step 2: Continued

RV_{INH}	is the release value for the inhalation pathway from EPA, 1989 Appendix E
f_3	is the ratio of the dose rate from a point source at 30 meters to the dose rate from a distributed source of equal activity at 30 meters
RV_{DIR}	is the release value for the direct exposure pathway from EPA, 1989 Appendix E

The potential accident scenarios and corresponding release fractions are identified from a hazard analysis. This final hazard categorization will be based on the hazard analysis in Roberson (2002) and the hazard event analyses presented in BHI (2005b). These analyses form the basis for identifying appropriate respirable airborne release fractions. The release fractions will be from DOE-HDBK-3010-94 (DOE, 2000), Roberson (2002), or other analyses previously approved by DOE. Equation 2 will be used to generate revised TQs for each constituent present.

The total inventory of radionuclides for the dominant material form, based on the most conservative or appropriate R value, is compared to the revised TQs for that form using the sum of the ratios. The FHC is based on the resultant sum of the ratios for that dominant scenario.

For conservatism, this final categorization will assume that f_2 is equal to 1 although there is no potential for releases to drinking water in the vicinity of the waste site. It will also assume that f_3 is equal to 1.

The adjustment factor f_1 can be expressed as: $f_1 = R_{EPA}/R_{HA}$.

Where,

R_{EPA} is the respirable release fraction for a hazardous material element (e.g., cobalt, aluminum, strontium) from EPA (1989), Exhibit A-1.

R_{HA} is the respirable release fraction for a particular hazardous material for the potential hazard identified in this hazard analysis.

In general, the respirable release fraction (R) is the product of the airborne release fraction (ARF) and the respirable fraction (RF), or R = ARF x RF.

Step 3: Determine the final hazard categorization.

The inventories for each constituent are divided by the revised TQ values. These individual ratios are then summed and compared to 1. If the sum of the ratios is above 1 using the revised TQ, then the revised TQ has been exceeded and the FHC for the waste site is determined to be Category 3. If the sum of the ratios is below 1, the FHC is determined to be below Category 3 or Radiological.

Bechtel Hanford, Inc. **CALCULATION SHEET**

Originator: M.W. Ellis		**Date:** 3/21/2007	**Calc. No.:** 0100C-CA-N0012	**Rev. No.:** 1	
Project: 116-C-3 Remediation	**Job No.:** 14655		**Checked:** T.J. Rodovsky TR	**Date:** 3/22/07	
Subject: 116-C-3 Final Hazard Categorization Calculation (Revised TQs)				**Sheet No.:** 5 of 12	

6.0 Hazard Analysis - Determination of Release Values Associated Release Mechanisms

6.1 Dump/Spill/Spray

Contaminated Soil or Grout Matrix: Dumping/Spilling of soil/grout could be initiated by several mechanisms: 1) operator loss of control of an excavator bucket during the loadout of the soil/pulverized grout matrix; or 2) spilling and resuspension of grouted material during tank shearing operations. The respirable ARF for dumping/spilling used in Roberson (2002) Attachment 4 is 1.0E-06. Therefore, the respirable release fraction (R value) used for dumping or spilling of contaminated soil/pulverized grout is 1.0E-06.

Contaminated, Combustible Solids: Contaminated combustible solids expected to be present during remediation activities of the 116-C-3 tanks are limited to used PPE, which may be stored in drums near the waste site. Used PPE will have minimal contamination and has a high surface area to mass ratio. Consequently, they would generate little force during impact with surfaces. DOE (2000), Section 5.2.3.1, states that no significant suspension of surface contamination is postulated for such materials. Therefore, dumping of contaminated, combustible solids is not considered further in this calculation.

Contaminated, Noncombustible Solids: Contaminated noncombustible solids, such as piping, will be excavated from the waste site during remediation activities. The solids may be lifted out of the excavation and dropped resulting a release of surface or internal contamination. Only loose contamination on the surface of the noncombustible solids would be subject to release (i.e., not embedded or combined with the surface matrix). The majority of the surface contamination on noncombustible solids is expected to be in the form of a scale which strongly adheres to the pipe or tank surfaces. DOE (2000), Section 5.3.3, addresses free-fall-spill and impaction stress to such solids. The bounding R value for shock-vibration of contaminated, noncombustible materials that do not undergo brittle fracture is 1.0E-03.

Contaminated Liquid/Sludge: The potential exists for liquid/sludge to be inadvertently released during grouting operations due to a loss of tank integrity from corrosion. Section 3.2.3.2 of DOE (2000) indicates a spill of aqueous solutions (i.e., slurries), 3-m fall distance, has a bounding R value of 4.0E-05.

The potential exists for liquid/sludge to be inadvertently released (pressurized spray release) during the pumping of the waste material from the tank to a solidification process outside the tank using a low pressure pump and piping/hose assembly operating at $\leq$ 50 psig. Section 3.2.2.3.2 of DOE (2000) indicates a pressurized spray release of aqueous solutions has a bounding R value of 4.0E-05.

6.2 High Wind/Entrainment

Contaminated Soil: Due to the high pH and the amount of liquid still left in the south tank, it is believed that the tank has not leaked. However, for conservatism, it is assumed that the tank has leaked and contaminated a 0.3-m thick layer of soil equal to the foot print of the tank (10.9 m in length x 3.7 m in diameter) or 12.1 m^3 of contaminated soil. The soil entrainment rate used in Attachment 4 of Roberson (2002) is 4.0E-03 g/m2-h, or 3.2E-02 g/m2-8h. [Note: An 8-hour exposure is selected consistent with DOE-STD-3009-94, Appendix A, Section A.3.3.] Equation 3 was used to calculate the entrainment R value of 6.3E-08 for this scenario.

$$R = ARF \times RF = [(SER)(SA)(T)]/[(p)(SV)] \qquad (3)$$

Where:

SER - Soil entrainment rate obtained from Attachment 4 of Roberson (2002) 4.0E-03 g/m^2-h
SA - Surface area of contaminated soil = 40.3 m^2
T - Time interval over which soil is exposed to wind (8 h)
p - Assumed soil density of 1.7g/cm^3 or 1.7E+06 g/m^3
SV - Contaminated soil volume = 12.1 m^3

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Bechtel Hanford, Inc. **CALCULATION SHEET**

Originator:	T. M. Blakley	Date: 7/26/2005	Calc. No.: 0100C-CA-N0012	Rev. No.:	0
Project:	116-C-3 Remediation	Job No.: 22192	Checked: M.F. Maxson	Date:	7/27/05
Subject:	116-C-3 Final Hazard Categorization Calculation (Revised TQs)			Sheet No.:	6 of 12

6.0 Hazard Analysis - Determination of Release Values Associated Release Mechanisms (continued)

Contaminated Combustible Solids: The 116-C-3 waste site contains no contaminated, combustible solids. Contaminated, combustible solids would, in all likelihood, be limited to used PPE contained in drums. The amount of contamination present on used PPE is anticipated to be minimal. A high wind event could resuspend freshly deposited surface contamination, but the bulk of the waste will be protected from high winds by the waste drum. Section 5.2.4 of DOE (2000) indicates that the bounding R value for this waste form is 4E-5/hr, or 3.2E-04 for an 8-hr duration. [Note: An 8-hr exposure is selected consistent with DOE-STD-3009-94, Appendix A, Section A.3.3.]

Contaminated Noncombustible Solids: Only loose contamination on the surfaces of noncombustible solids would be available for entrainment by high winds (i.e., not combined with or embedded in the surface matrix). The majority of the surface contamination, on noncombustible solids, is expected to be in the form of a scale that is strongly affixed to the pipe or tank surfaces. The inventory in this form, potentially subjected to high wind entrainment, is anticipated to be minimal. Section 5.3.4 of DOE (2000) indicates that the bounding R value for the entrainment of a sparse population of loose surface contamination from a noncombustible surface is 4E-5/hr, or 3.2E-04 for an 8-hr duration. [Note: An 8-hr exposure is selected consistent with DOE-STD-3009-94, Appendix A, Section A.3.3.]

Contaminated Liquid/Sludge: Liquid/sludge inadvertently released from the waste tanks may be entrained by wind during grouting activities. Liquid/sludge or grouted material remaining in the tanks is protected from entrainment by wind. Section 3.2.4.5 of DOE (2000) indicates that the bounding R value for an outdoor pool at low windspeeds is 4E-7/hr, or 3.2E-06 for an 8-hr duration. [Note: An 8-hr exposure is selected consistent with DOE-STD-3009-94, Appendix A, Section A.3.3.]

6.3 EXPLOSION (FLAMMABLE GAS/AIR MIXTURE DEFLAGRATION)

Contaminated Solidified Matrix: The pressure rise generated by a flammable gas/air mixture deflagration during remediation activities could cause a resuspension of contaminated partially solidified or fragmented material from within the tank. However, large amounts of fuel (hundreds of pounds or more) are generally required for a flammable gas/air mixture to form an unconfined cloud within the fuel's flammable limits that then subsequently explodes. Such amounts of fuel will not be present during remediation activities. The tanks could potentially serve as a confining space for a flammable gas/air mixture, but they are vented to atmosphere. If a deflagration were to occur within a tank, a small amount of contaminated partially solidified material could be resuspended.

Section 4.3.2.2 of DOE (2000) states that pressure impulses generated by an explosive event that may entrain and hurl aggregate materials will not result in significant airborne releases unless aggregate materials are hurled at considerable velocities. It is estimated that the contaminated material that could be resuspended is negligible; therefore, contaminated solidified matrix materials are not considered further in this calculation.

Contaminated Combustible Solids: Contaminated combustible solids expected to be present during remediation activities of the 116-C-3 tanks are limited to used PPE, which may be stored in drums near the waste site. Used PPE will have minimal contamination and does not provide a rigid surface for pressurized gases to act upon. DOE (2000), Section 5.2.2.3, states that the bounding R value for this scenario is 1E-03.

Contaminated Noncombustible Solids: Small amounts of contaminated noncombustible solids, such as piping, will be exposed during remediation activities. The majority of the surface contamination, on noncombustible solids, is expected to be in the form of a scale that is strongly affixed to the pipe or tank surfaces. Section 5.3.2.3 of DOE (2000) indicates that the bounding R value for the release of pressurized gases over contaminated, noncombustible materials is 2E-03.

Contaminated Liquid/Sludge: It is possible that a deflagration could occur within a tank during grouting activities. However, because the amount of flammable gases will be relatively small and the tanks are vented to atmosphere, the potential damage is anticipated to be low. It is believed that most of the partially grouted liquid/sludge or grouted material in the tanks would not be affected by a deflagration in the headspace. Section 3.2.2.3.2 of DOE (2000) indicates that the bounding R value for an overall vessel failure would be 4E-5. Given that the waste site consists of tanks that will be mostly underground throughout remediation activities, it is believed that this value is very conservative.

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Originator: T. M. Blakley JMB	Date: 7/25/2005	Calc. No.: 0100C-CA-N0012	Rev. No.: 0
Project: 116-C-3 Remediation	Job No.: 22192	Checked: M.F. Maxson MFM	Date: 7/27/05
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6.0 Hazard Analysis - Determination of Release Values Associated Release Mechanisms (continued)

6.4 VEHICLE/EXCAVATOR IMPACT

Contaminated Soil/Pulverized Grout: A vehicle or excavator impact to contaminated soil or the contaminated soil pulverized grout matrix could result in resuspension of the material. However, only a small fraction of the potentially contaminated volume could be affected. Section 4.4.3.3.2 of DOE (2000) is not directly applicable to this scenario due to the physical differences between the experimental conditions (powder placed on a plywood sheet or in a quart can within a vented metal box) and the tank remediation activities but it does provide a reference point. The bounding R value in Section 4.4.3.3.2 of DOE (2000) is 2E-03.

Contaminated Combustible Solids: Contaminated combustible solids expected to be present during remediation activities of the 116-C-3 tanks are limited to used PPE, which may be stored in drums near the waste site. Used PPE will have minimal contamination. Vehicle/equipment impact to packaged, contaminated PPE could result in a failure of the drum and suspension of surface contamination. Section 5.2.3.2 of DOE (2000), states that the bounding R value for this scenario is 1E-04.

Contaminated Noncombustible Solids: Contaminated noncombustible solids, such as piping, will be exposed during remediation activities. Contaminated particles adhering to the surface of the noncombustible solids would be subject to release by impact due to the resultant flexing of the solid. The majority of the surface contamination, on noncombustible solids, is expected to be in the form of a scale that strongly affixed to the pipe or tank surfaces and most of this will, in turn, be protected from impact by at least 2 feet of soil. Section 5.3.3.2.2 of DOE (2000) indicates that the bounding R value for impact to contaminated, noncombustible materials that do not brittle fracture is 2E-03.

Contaminated liquid/sludge: It is possible that an impact to a tank could occur during grouting activities. However, because the bulk of the tanks will remain underground, any impact is expected to be limited to the top section of a tank. It is expected that most of the ungrouted liquid/sludge or grouted liquid/sludge in the tanks would not be affected by an impact. Section 3.2.2.3.2 of DOE (2000) indicates that the bounding R value for an overall vessel failure would be 4E-05. Given that overall vessel failure would probably not occur as a result of an impact, it is believed that this value is very conservative.

6.5 FIRE

Contaminated Soil or Grout Matrix: The area surrounding the 116-C-3 site consists of cobbles without significant amounts of vegetation. The contaminated soil or contaminated grout associated with the 116-C-3 remediation is noncombustible. Fire is judged to result in an insignificant release.

Contaminated Combustible Solids: Combustible solids expected to be present during remediation activities of the 116-C-3 tanks are limited to used PPE, which may be stored in drums near the waste site. PPE will have minimal amounts of contamination. Section 5.2.1.1 of DOE (2000) indicates that the bounding R value for packaged, contaminated combustible materials that are heated/burned is 5E-04. This value was judged to be bounding for conditions under consideration (e.g., ignition of the soft waste from an external source such as a range fire or an internal source such as a vehicle fire).

Contaminated Noncombustible Solids: A fire could eject some of the contamination from the metal tank or pipe surfaces due to flexing of the solid surface. Tanks, piping, structural components, concrete, underground transfer lines, etc. will be size reduced utilizing cutting torches, hydraulic shears, grinders, snippers, wire saws or by mechanical disassembly, as applicable. Section 5.3.1 of DOE (2000) indicates that the bounding R value for this event is 6E-05. It is expected that only a small fraction of the total inventory would be subject to release by this mechanism.

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Bechtel Hanford, Inc. **CALCULATION SHEET**

Originator: M.W. Ellis	**Date:** 3/22/2007	**Calc. No.:** 0100C-CA-N0012	**Rev. No.:** 1		
Project: 116-C-3 Remediation	**Job No.:** 14655	**Checked:** T.J. Rodovsky DR	**Date:** 3/22/07		
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6.5 Fire (Continued)

Contaminated Liquid/Sludge: A potential initiator of an onsite fire could be ignition of gasoline or diesel from the excavator. It is possible for the piping/tanks to be heated by a fire and, as a result, the unsolidified liquid/sludge contents could also be heated. It is anticipated that the energy input from a worst-case fire would be insufficient to result in boiling of the liquids. Section 3.2.1.1 of DOE (2000) indicates that the bounding R value for heating of shallow pools of aqueous solutions is 3E-05, which is based on experiments involving ml volumes of solution in a shallow steel dish. While this is not directly applicable to the situation of heating 34,800 L (9,193 gallons) of liquid/sludge, it does provide a reference point. The R value for heating of the liquid/sludge would be expected to be significantly less than 3E-05.

6.6 Summary Of Release Values

	Release Mechanism					
Waste Form	**Dump/Spill/ Spray**	**Entrainment[a]**	**Deflagration**	**Vehicle Impact**	**Fire**	**Bounding R Value**
Contaminated Soil or Grout	1E-6	2E-7	<<2E-3	<<2E-3	Negligible	1E-6
Liquid/Sludge	4E-5	3.0E-6	4E-5	<4E-5	<<3E-5	**4E-5**
Contaminated Combustibles	Negligible	3.0E-4	1E-3	1E-4	5E-4	1E-3
Contaminated Noncombustibles	1E-3	3.0E-4	2E-3	2E-3	6E-5	2E-3

[a] Entrainment rates based on an 8 hr duration. See Section 6.2, Sheets 5-6.

Nearly all of the radiological inventory associated with the 116-C-3 chemical storage tanks is expected to be in the form of contaminated liquid/sludge contained within the tanks solidified or unsolidified depending on the remediation stage. The inventory associated with the other two waste forms (combustible and noncombustible) is expected to be orders of magnitude less. Based on the bounding R value determined for each waste form and the potential radiological inventory associated with each form, it is believed that a bounding R value of 4E-5, as determined for liquid/sludge, is a reasonably conservative value to apply to the entire inventory of the tanks for FHC purposes. It is recognized that some events, particularly those involving contaminated combustibles and contaminated noncombustibles, can produce higher values. Conversely, some events involving contaminated soil would produce smaller values. However, the higher release events would only affect a small fraction of the total inventory.

0100C-CA-N0012_Rev_1_116-C-3_FHC Revised TQ Values 112206/Calc (8) (Hazard Anal Cont.)

Bechtel Hanford, Inc. **CALCULATION SHEET**

Originator: T. M. Blakley TMB	Date: 7/25/2005	Calc. No.: 0100C-CA-N0012		Rev. No.: 0	
Project: 116-C-3 Remediation	Job No.: 22192	Checked: M.F. Maxson MFM		Date: 7/27/05	
Subject: 116-C-3 Final Hazard Categorization Calculation (Revised TQs)				Sheet No.: 9 of 12	

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0100C-CA-N0012_Rev_0_116-C-3_FHC Revised TQ Values/Calc (9) (References)

Bechtel Hanford, Inc. **CALCULATION SHEET**

Originator: T. M. Blakley Date: 7/25/2005 Calc. No.: 0100C-CA-N0012 Rev. No.: 0
Project: 116-C-3 Remediation Job No.: 22192 Checked: M.F. Maxson Date: 7/27/05
Subject: 116-C-3 Final Hazard Categorization Calculation (Revised TQs) Sheet No.: 10 of 12

8.0 Inventory of North and South Tanks

Isotope	Steel (Ci)[a]	Soil (Ci)[a]	Liquids (Ci)[a]	Sludge (Ci)[a]	Total Inventory (Ci)
Am-241	--	--	--	4.1E-01	4.1E-01
C-14	2.4E-04	4.8E-04	7.1E-04	3.0E-04	1.7E-03
Co-60	1.1E-04	2.2E-04	3.3E-04	2.1E-02	2.2E-02
Cs-137	3.5E-01	7.1E-01	1.1E+00	2.9E-01	2.4E+00
Eu-152	--	--	--	2.8E-03	2.8E-03
Eu-154	--	--	--	3.3E-03	3.3E-03
H-3	6.7E-04	1.4E-03	2.0E-03	7.6E-05	4.1E-03
Ni-63	--	--	--	6.9E+00	6.9E+00
Pu-238	--	--	--	8.6E-03	8.6E-03
Pu-239/240	--	--	--	1.8E+00	1.8E+00
Pu-241[b]	--	--	--	1.8E+00	1.8E+00
Sr-90	2.9E-02	5.9E-02	8.7E-02	7.6E+00	7.8E+00
U-233/234	4.0E-05	8.1E-05	1.2E-04	4.5E-03	4.7E-03
U-238	4.3E-05	8.8E-05	1.3E-04	4.6E-03	4.8E-03
Y-90[c]	2.9E-02	5.9E-02	8.7E-02	7.6E+00	7.8E+00
Total	**4.1E-01**	**8.3E-01**	**1.2E+00**	**2.6E+01**	**2.9E+01**

[a]Inventory calculated in MAR calculation 0100C-CA-N0011, Rev. 0 (BHI 2005).

[b] Although not included in laboratory analyses, an inventory for Pu-241 have been included above for sludge. Assuming weapons-grade Pu and 45 year-old material, the inventory for Pu-241 has been estimated to be equal to that of Pu-239/240 (based on a Pu-241:Pu-239/240 ratio of 1 for the sludge material in the 116-C-3 tanks). Other isotopes (e.g., U-235) would also be expected; however, the inventory from such isotopes are considered negligible contributors to the sum-of-the ratios values.

[c]Y-90 is assumed to be secular equilibrium with its parent Sr-90. Ba-137m is also in secular equilibrium with its parent Cs-137 but since there is no EPA Release Values reported in EPA (1989) this radionuclide was not included in the FHC Calcs.

0100C-CA-N0012_Rev_0_116-C-3_FHC Revised TQ Values/Calc (10) (N&S Tank Inventory)

Bechtel Hanford, Inc. **CALCULATION SHEET**

Originator:	T. M. Blakley *TMB*	Date:	7/25/2005	Calc. No.:	0100C-CA-N0012	Rev. No.:	0
Project:	116-C-3 Remediation	Job No.:	22192	Checked:	M.F. Maxson *MFM*	Date:	*7/27/05*
Subject:	116-C-3 Final Hazard Categorization Calculation (Revised TQs)					Sheet No.:	11 of 12

10.0 Calculation of Revised TQ Values

CATEGORY 3 THRESHOLD QUANTITIES REVISED FOR APPROPRIATE RELEASE VALUES

Element	R_{EPA} (1)	R_{HA}	Food(2) Ingestion RV (Ci)	Adjusted(3) Food Ingestion RV (Ci)	Water(4) Ingestion RV (Ci)	Inhalation(5) RV (Ci)	Adjusted(3) Inhalation RV (Ci)	Direct(6) Exposure RV (Ci)	$TQ_{REVISED}$ (7) (Ci)
Am-241	1.E-03	4.0E-05	3.0E-01	7.5E+00	v. lg.	2.6E-02	7.E-01	--	1.3E+01
C-14	5.E-01	4.0E-05	--	--	1.5E+02	2.1E+01	3.E+05	--	3.0E+03
Co-60(8)	1.E-03	4.0E-05	6.0E+01	1.5E+03	v. lg.	1.6E+02	4.E+03	1.5E+01	2.8E+02
Cs-137	1.E-02	4.0E-05	3.0E+00	7.5E+02	v. lg.	1.0E+02	3.E+04	6.5E+01	1.3E+03
Eu-152	1.E-02	4.0E-05	2.4E+01	6.0E+03	v. lg.	1.0E+01	3.E+03	3.5E+01	7.0E+02
Eu-154	1.E-02	4.0E-05	1.5E+01	3.8E+03	v. lg.	1.0E+01	3.E+03	4.2E+01	8.4E+02
H-3	5.E-01	4.0E-05	--	--	5.9E+03	8.3E+02	1.E+07	--	1.2E+05
Ni-63	1.E-02	4.0E-05	2.7E+02	6.8E+04	v. lg.	1.0E+03	3.E+05	--	1.4E+06
Pu-238	1.E-03	4.0E-05	2.1E+00	5.3E+01	v. lg.	3.1E-02	8.E-01	--	1.6E+01
Pu-239/240	1.E-03	4.0E-05	1.8E+00	4.5E+01	v. lg.	2.6E-02	7.E-01	1.7E+06	1.3E+01
Pu-241	1.E-03	4.0E-05	9.0E+01	2.3E+03	v. lg.	1.6E+00	4.E+01	1.4E+08	8.0E+02
Sr-90	1.E-02	4.0E-05	8.2E-01	2.1E+02	v. lg.	2.1E+00	5.E+02	--	4.1E+03
U-233/234	1.E-03	4.0E-05	3.0E+00	7.5E+01	v. lg.	2.1E-01	5.E+00	7.5E+05	1.1E+02
U-238	1.E-03	4.0E-05	3.0E+00	7.5E+01	v. lg.	2.1E-01	5.E+00	--	1.1E+02
Y-90	1.E-02	4.0E-05	7.1E+01	1.8E+04	v. lg.	3.1E+02	8.E+04	--	3.6E+05

Notes:

v. lg. Indicates that the sorption coefficient is greater than zero and the release value is much greater than that for other pathways (EPA, 1989).

-- indicates that no gamma rays are emitted or the gamma rays which are emitted have gamma ray energies of less than 0.07 MeV and are strongly attenuated in air. No release value for the direct exposure pathway was calculated (EPA, 1989).

(1) As reported in Appendix A of "Technical Background Document to Support Final Rulemaking Pursuant to Section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act: Radionuclides", EPA Contract 68-03-3452, 02/89

(2) A release of RV to atmosphere produces a dose of 0.5 rem via the food ingestion pathway. Assumes deposition on crops 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed (X/Q = 0.072 m^3/sec).

(3) Food ingestion and inhalation RVs adjusted by multiplying each original value by ratio of (R_{EPA} / R_{HA}). See note 7 below.

(4) A release of RV to groundwater produces a dose of 0.5 rem via the water ingestion pathway. Assumes a well 30 meters from the point of release. Contact time = 9 days. Independent of the airborne release fraction.

(5) A release of RV to atmosphere produces a dose of 0.5 rem via the inhalation pathway. Assumes a receptor 30 meters from the point of release. Dispersion based on extrapolation of ground level data for stability class D and 1 m/sec windspeed (X/Q = 0.072 m^3/sec) and average breathing rate (2.7E-4 m^3/sec).

(6) A point source of RV produces a dose of 0.5 rem at 30 meters in 24 hours. Independent of airborne release fraction.

(7) TQ = 20 x the minimum value of {(Food RV x R_{EPA}/R_{HA}), Water RV, (Inhalation RV x R_{EPA}/R_{HA}), or Direct Dose RV}. The value "20" results from the EPA RVs being based on an effective dose of 0.5 rem and the 1027 values being based on an effective dose of 10 rem (i.e., [0.5 rem x 20 = 10 rem]).

(8) The most restrictive value from EPA (1989) is direct exposure. 20 times this value is 300 Ci. The TQ listed in DOE 1997 is 280 Ci. The more restrictive value of 280 Ci is used.

0100C-CA-N0012_Rev_0_116-C-3_FHC Revised TQ Values/Calc (11) Rev TQ

Bechtel Hanford, Inc. **CALCULATION SHEET**

Originator:	T. M. Blakley TMB	Date:	7/25/2005	Calc. No.: 0100C-CA-N0012	Rev. No.: 0
Project:	116-C-3 Remediation	Job No.:	22192	Checked: M.F. Maxson MFM	Date: 7/27/05
Subject:	116-C-3 Final Hazard Categorization Calculation (Revised TQs)				Sheet No.: 12 of 12

11.0 Sum of the Ratios

Isotope	Inventory At Risk (Ci)[1]	1027 CATEGORY 3 $TQ_{ORIGINAL}$ (Ci)[2]	$TQ_{REVISED}$ (Ci)[3]	RATIO
Am-241	4.1E-01	5.2E-01	1.3E+01	3.2E-02
C-14	1.7E-03	4.2E+02	3.0E+03	5.8E-07
Co-60	2.2E-02	2.8E+02	2.8E+02	7.8E-05
Cs-137	2.4E+00	6.0E+01	1.3E+03	1.9E-03
Eu-152	2.8E-03	2.0E+02	7.0E+02	4.0E-06
Eu-154	3.3E-03	2.0E+02	8.4E+02	3.9E-06
H-3	4.1E-03	1.6E+04	1.2E+05	3.5E-08
Ni-63	6.9E+00	5.4E+03	1.4E+06	5.1E-06
Pu-238	8.6E-03	6.2E-01	1.6E+01	5.6E-04
Pu-239/240	1.8E+00	5.2E-01	1.3E+01	1.4E-01
Pu-241	1.8E+00	3.2E+01	8.0E+02	2.2E-03
Sr-90	7.8E+00	1.6E+01	4.1E+03	1.9E-03
U-233/234	4.7E-03	4.2E+00	1.1E+02	4.5E-05
U-238	4.8E-03	4.2E+00	1.1E+02	4.6E-05
Y-90	7.8E+00	1.4E+03	3.6E+05	2.2E-05
			Sum of Ratios:	1.7E-01

Calculations

RATIO (CATEGORY 3) = MAR/1027 CATEGORY 3 REVISED TQ (Ci)

Notes:

[1]Total radionuclide inventory from Sheet 10.

[2]Original TQ value is from DOE-STD-1027.

[3]The revised TQ values are calculated on Sheet 11.

0100C-CA-N0012_Rev_0_116-C-3_FHC Revised TQ Values/Calc(12) (Sum of Ratios)

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